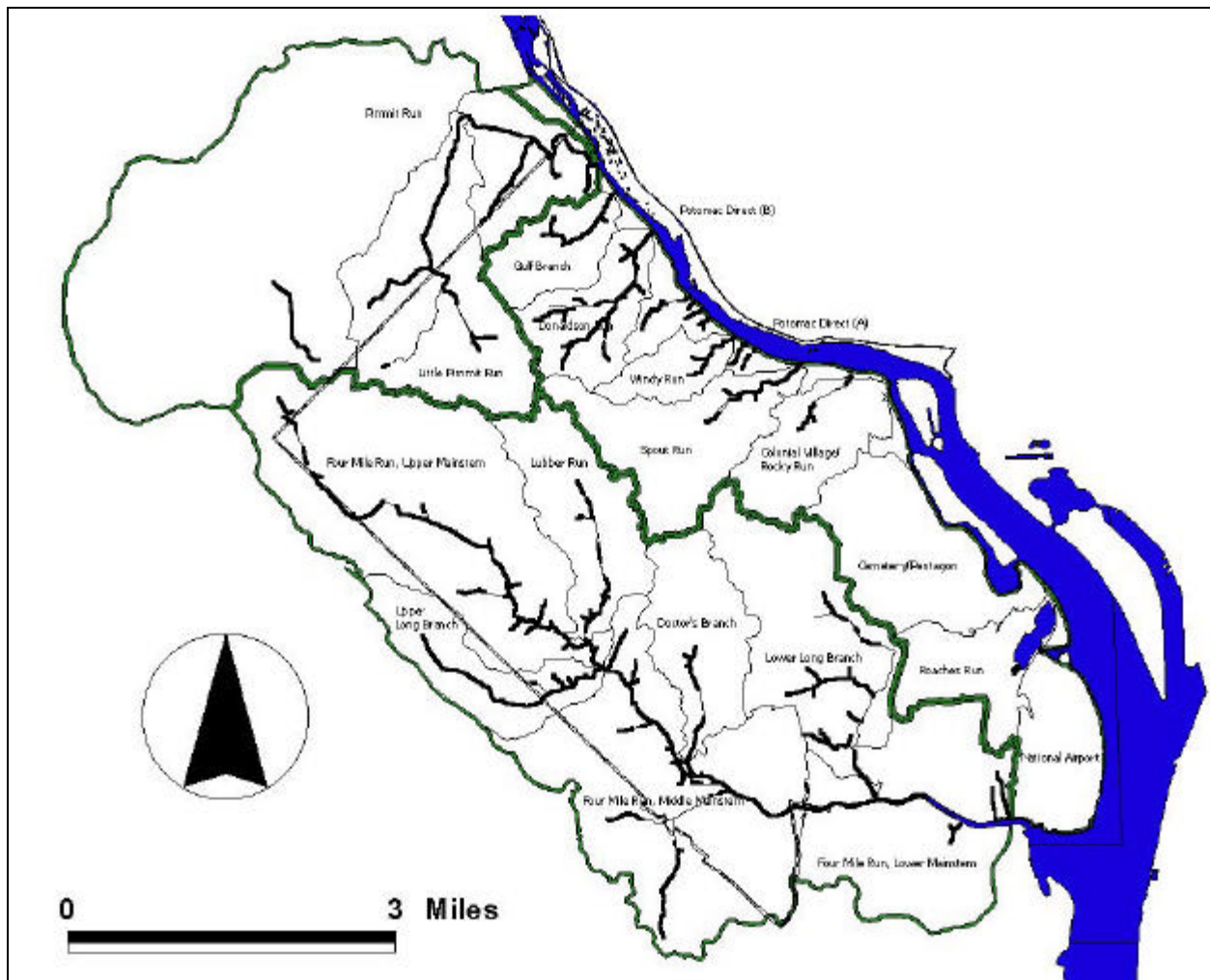




Arlington County Virginia

Watershed Management Plan



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Executive Summary

Arlington County received a grant in late-1998 from the Virginia Department of Environmental Quality to assist with the preparation of a Watershed Management Plan. The County's Stormwater Master Plan, adopted by the County Board in 1996, identified the need for a Watershed Management Plan to address a variety of problems affecting Arlington's streams and adjacent riparian areas.

For example, Arlington is mostly built-out, and almost 40 percent of its total area is covered by impervious surfaces such as streets, buildings, driveways, and sidewalks. Serious stream degradation has been shown to occur when levels of impervious cover exceed 25 percent, according to numerous studies.

More than half of the County's original stream network has been replaced by a dense network of underground storm sewers. During storms, these storm sewers convey a large volume of runoff and pollutants to streams at high velocities, causing streambank erosion, water quality problems, and habitat degradation. Much of the County was developed before local environmental statutes that address water quality and water quantity, like the Chesapeake Bay Preservation Ordinance and the Stormwater Detention Ordinance, took effect. Therefore, most of the development that now exists in the County does not adequately address the impact of this development on County streams.

In addition, an imperfect mix of federal, state, and local regulations and regional programs exists in an effort to protect human health and aquatic ecosystems from the effects of development. Arlington is subject to several such regulatory programs, as well as the Chesapeake Bay Agreement, a highly visible regional program that addresses multiple environmental problems and endpoints. Most of these programs share a common goal: improved water quality, safe recreation for citizens, and healthy aquatic ecosystems. However, none of these programs fully address the effects of existing development on local streams and riparian zones. As a result, many Arlington streams are degraded and suffer from a variety of problems that are not addressed by current County programs or policies.

A Countywide stream inventory conducted in 1999 as part of the DEQ grant found that most County streams were in fair condition—and no County streams were evaluated to be in excellent condition. The inventory found 40 locations with active streambank erosion and 70 locations where riparian buffers are in poor condition. Litter is a pervasive problem in streams because storm sewers are very efficient litter delivery systems. There is also evidence of recurring spills and leaks that adversely affect water quality.

Bacteria levels in Four Mile Run, like most urban streams, routinely exceed water quality standards. Unfortunately, a DNA study recently completed by the Northern Virginia Regional Commission (NVRC—formerly the Northern Virginia Planning District Commission (NVPDC)) suggests that most sources of bacteria in Arlington streams are not readily controllable because they come from urban wildlife. Waterfowl, raccoon, and deer accounted for over 60 percent of the bacterial DNA samples collected in the Four Mile Run watershed. In contrast, human DNA was identified in 17 percent of the samples, while dog DNA was identified in only nine percent of the samples.

At the same time, the County's stream valley parks are a magnet for residents, and the pressure on these riparian systems increases as population increases. Local problems in County streams also contribute to regional water quality problems in the Potomac River and Chesapeake Bay. As a result, the combined need to protect local streams and comply with multiple state, regional, and federal programs reinforce the importance of comprehensive watershed management.

The challenge for Arlington is to come up with a coordinated watershed management strategy, since complying with one federal or state program does not guarantee compliance with others. The Watershed Management Plan provides the framework for such a strategy.

The Watershed Management Plan analyzes existing County water resource and runoff management practices; sets management goals for County subwatersheds based on existing stream conditions, current land use, and future land use changes; provides overall management recommendations for County subwatersheds; and lays out an implementation plan. The technical document addresses five components that provide a roadmap for watershed management. These components include: i) stormwater runoff and dry weather pollution control; ii) stormwater Best Management Practices (BMPs), BMP retrofits, and maintenance; iii) stormwater infrastructure maintenance; iv) stream and riparian buffer management, restoration, and monitoring; and, v) public information and outreach.

It is fortuitous that at the same time the County received a grant from DEQ to prepare a Watershed Management Plan, the County Board also appointed the Chesapeake Bay Preservation Ordinance Task Force, since the Task Force recommendations complement the recommendations in the Watershed Management Plan. The Task Force was formed in response to a number of community concerns about the impact of in-fill development on the County's remaining headwater streams. The key Task Force recommendations focus on the need for more comprehensive plan review and more frequent inspections of development sites, while the Watershed Management Plan provides a broad framework for water resources management. The Plan addresses programs like stream restoration and stormwater BMPs and infrastructure maintenance, and generally supports the sorts of ordinance changes recommended by the Task Force.

Organization of the Watershed Management Plan

This plan divides the County into 19 subwatersheds, ranging in size from 0.3 square miles to 5 square miles. The document:

- Analyzes existing County water resource and runoff management practices;
- Establishes management goals for each of the County subwatersheds based on existing stream conditions, current land use, and future land use changes;
- Translates subwatershed goals into specific management recommendations; and
- Provides a plan for implementation.

For both existing and recommended County water resources and runoff management practices, the plan covers five components that provide a logical framework for watershed management:

- 1) Addressing the **sources of stormwater runoff and dry weather pollution** from existing and new development, point sources, or illegal discharges;
- 2) Implementing and maintaining **Best Management Practices (BMPs)**¹ to control stormwater pollution;
- 3) Maintaining **stormwater infrastructure**;
- 4) Managing, restoring, and monitoring **streams and buffers**; and
- 5) Implementing **pollution prevention** and **watershed education** initiatives.

¹ Best Management Practices or BMPs are structural or nonstructural practices, or a combination of practices, designed to act as effective, practicable ways to minimize the impacts of development and human activity on water quality. Structural BMPs, which include extended detention dry ponds, wet ponds, infiltration trenches, sand filters, and in-line filters, rely heavily on gravitational settling and/or infiltration through a porous medium for pollutant removal. Nonstructural BMPs range from programs that increase public awareness to prevent pollution to vegetation-utilizing controls such as bioretention areas or wetlands (NVPDC, 1996).

Summary of Major Findings and Recommendations

Existing County water resource and runoff management practices

Arlington County is responsible for a variety of programs that address stormwater runoff and implements a number of educational and pollution prevention initiatives. The Watershed Management Plan concludes that:

- There are significant gaps in County water resource management programs, including inadequate control of runoff from existing development, lack of stream monitoring, and lack of systematic, prioritized stream restoration programs;
- The County needs to improve regulations that govern new development and redevelopment in the County to protect and preserve streams and riparian buffers, including the Storm Water Detention Ordinance, the Chesapeake Bay Preservation Ordinance, and the Erosion and Sediment Control Ordinance.

Baseline subwatershed conditions

Streams

- The DES Environmental Planning Office (EPO) hired a consultant to conduct a stream and riparian buffer inventory during the spring and summer of 1999;
- The inventory data suggest most County subwatersheds are in 'fair' condition, with generally better stream conditions in the lower-density Palisades area as well as in stream-valley parks.

Current and future land use

- Arlington County is an 'ultra urban' jurisdiction—most of the County is already 'built-out';
- The largest percentage of remaining undeveloped land in any County subwatershed is only seven percent;
- Current conditions closely match projections of future land use based on what is allowed under the Zoning Ordinance and the General Land Use Plan.

Subwatershed goals

All of Arlington's streams have been impacted by development. The County's urban subwatersheds can therefore be classified as 'least impacted', 'more impacted', and 'most impacted,' based on the amount of impervious cover and the results of a detailed stream inventory.

- Least impacted subwatersheds: Gulf Branch and Donaldson Run
 - Management goals include reducing the rate and volume of stormwater runoff, reducing stormwater pollution, especially sediment, nutrients, and bacteria², stabilizing eroded stream channels, improving in-stream and riparian habitat, and improving the diversity of macroinvertebrate organisms that live in County streams (based on Caraco et al., 1998);
- More impacted subwatersheds: Little Pimmit Run, Lower Long Branch, and Windy Run
 - Management goals for these subwatersheds include preventing further increases in the rate and volume of stormwater runoff, reducing stormwater pollution, especially sediment, nutrients, and bacteria, stabilizing eroded stream channels, preventing degradation of in-stream and riparian habitat, and maintaining the diversity of the macroinvertebrate community (based on Caraco et al., 1998);
- Most impacted subwatersheds: Lower Long Branch, Doctors Branch, Spout Run, Lubber Run, Colonial Village/Rocky Run, and Upper, Middle, and Lower Four Mile Run
 - Management goals for these subwatersheds include minimizing increases in the rate and volume of stormwater runoff, reducing flooding, and minimizing sediment, nutrients, and bacteria loads to Four Mile Run and the Potomac River (based on Caraco et al., 1998);

² These goals are consistent with the Chesapeake Bay Agreement and Potomac Tributary Strategy goals, as well as local and State concerns over water quality standards violations due to bacteria.

- For all three categories of subwatersheds, management goals should also include expanding stream valley parks and improving aesthetic conditions.

Watershed management recommendations

Sources of stormwater runoff and dry weather pollution

- In Arlington, existing development is responsible for most runoff generated during storms.
 - Runoff from existing development can only be controlled at or near the source if a BMP retrofit or other water quality/quantity reduction measure is employed;
- For new development, redevelopment, and construction, the County should enforce existing ordinances regulating such activities (Stormwater Detention, Chesapeake Bay Preservation, Erosion and Sediment Control) as strictly as possible;
- The County could also improve provisions of Storm Water Detention Ordinance and Chesapeake Bay Preservation Ordinance;
 - In April 2000, a County Board-appointed task force provided recommendations to strengthen the Chesapeake Bay Preservation Ordinance;
 - The County's existing Stormwater Detention Ordinance, enacted County-wide in 1982, pre-dates the State of Virginia's Stormwater Management Act of 1990;
 - Virginia revised its voluntary stormwater management regulations in March 1998, but Arlington is not required to promulgate new local stormwater management ordinance consistent with state regulation since the County's ordinance pre-dates the State law;
 - Arlington must consider whether efforts to develop and implement a new stormwater management ordinance that addresses only new development and redevelopment is worth the stream channel and water quality benefits that could be incorporated into a new ordinance in a built-out jurisdiction such as Arlington.

Stormwater BMPs, BMP retrofits, and maintenance

Arlington's National Pollutant Discharge Elimination System (NPDES) storm water permit (also known as a Municipal Separate Storm Sewer System, or MS4, permit), provides legal obligation and authority to control runoff from existing development to the 'maximum extent practicable' by:

- 1) Reducing pollutants discharged to the MS4 in runoff from commercial and residential areas;
 - 2) Detecting and eliminating illicit discharges and/or improper disposal into MS4;
 - 3) Reducing pollutants in stormwater runoff from construction sites.
- Implementation of the first item has been limited for existing or new development and redevelopment;
 - Failure to address stormwater runoff from existing development could result in enforcement actions by the State of Virginia under the NPDES stormwater program;
 - Inaction could also subject the County or the State of Virginia to the possibility of citizen suits under the Clean Water Act;
 - Total Maximum Daily Load³ (TMDL) regulations will directly affect Four Mile Run, since it is listed on Virginia's 303(d) listing of impaired waters for exceeding State water quality standards for fecal coliform bacteria. This underscores the need for effective stormwater management programs to address both runoff quality and quantity.

³ The TMDL program requires states to determine the maximum pollutant loads that can be delivered to impaired waterbodies so that these rivers, lakes, and estuaries can meet water quality standards. Four Mile Run, which drains a large portion of Arlington County, will fall under this program because the stream does not meet water quality standards for fecal coliform bacteria. The development of TMDLs is a data and resource intensive process, and states and municipalities that begin to collect watershed information now—and start to reduce stream pollution—will be in a strong position to comply with these regulations.

This plan recommends the following BMP implementation strategy for the County, listed in an 'upstream-downstream' treatment hierarchy. By reducing pollutant loads to County streams, this approach will help ensure compliance with the County's MS4 permit. Because of the limited open space in the County, Arlington County should explore these BMP retrofit opportunities wherever feasible.

- Source control:
 - Implement high-efficiency street sweeping and increase the frequency of sweeping;
 - According to some studies, high efficiency sweepers may represent the best method of improving water quality in Arlington's older urban watersheds (NVRC, 1998).
- Treatment upgradient of storm sewers and streams:
 - The County needs to complete the existing BMP inventory and identify potential retrofits to improve detention capacity and pollutant removal efficiency;
 - The County should explore site-level and small drainage area BMPs.
- Treatment between surface drainage/storm sewer interface and storm sewer/stream interface:
 - The County should install in-line devices wherever appropriate to filter stormwater at strategic locations within the storm sewer system (especially high risk or chronic spill areas);
- Treatment downstream of storm sewer/stream interface:
 - The County should continue to explore recommendations of the 1993 NVRC report that identified and investigated the feasibility of 24 regional BMP sites in the Four Mile Run watershed;
 - The County should assess the feasibility of regional BMPs in other County subwatersheds.

It must be stressed that without regular inspections and maintenance, structural BMP strategies will not be successful. Therefore, it is imperative that the County identify funding and/or procedures not only to retrofit or install BMPs but also to inspect and maintain them.

Stormwater infrastructure

Arlington County implements a systematic storm sewer and sanitary network inspection and maintenance program.

- However, the stream inventory revealed locations with utility crossing and storm sewer outfall problems;
- County staff that observe stormwater infrastructure problems in the field should report observations of problems to supplement this program.

Stream and buffer management, restoration and monitoring

The stream inventory provides comprehensive information to prioritize and coordinate stream and buffer management in the County, including:

- Stabilizing badly eroded channels;
- Restoring instream habitat;
- Re-establishing riparian cover, consistent with the Chesapeake Bay Program goal of reforesting stream buffers in the 64,000 square mile Bay watershed;
- Improving stream aesthetics;
- Restoring the most degraded stream reaches.

During the stream inventory, Arlington County established 15 long-term monitoring stations in 10 subwatersheds.

- Stations will serve as focal points for future in-stream monitoring;
- Monitoring objectives include:
 - Refining baseline subwatershed conditions;
 - Assessing progress towards the management goals for three categories of subwatersheds;
 - Determining the extent, magnitude, and variability of fecal coliform pollution in the Four Mile Run watershed;

- Volunteers will be critical to success of a monitoring program.

Pollution prevention and watershed education

Pollution prevention and watershed education programs can be categorized as:

- Programs targeting citizens;
 - Arlington County, NVRC, Arlingtonians for a Clean Environment (ACE), and the Virginia Cooperative Extension implement a number of such programs;
 - Public education activities could be improved by better communication among responsible agencies, but programs are generally well-run and moderately effective. Future efforts should consider mass media like radio, newspaper, and television, as well as the Internet, because of their proven effectiveness in reaching a broader audience.
- Programs targeting public and private entities, such as County facilities, private businesses, and developers;
 - The County should develop brochures that describe Arlington's legal responsibility to control stormwater runoff and stream pollution; explain how buildings, parking lots, and typical site operations contribute to increased stormwater runoff and stream pollution; and suggests what can be done to reduce these impacts;
 - For new development/redevelopment, the Green Building Pilot Program could serve as a mechanism to encourage site design that minimizes stormwater runoff;
 - A County-wide stormwater management voluntary program could be created to set targets for reducing runoff and pollution from different types of sites;
 - For residents, schools, and non-profit groups, the Source Control Fund could support an annual small watershed grants program to support small-scale site restoration, monitoring, or education activities.
- Programs targeting County employees responsible for stream and buffer management;
 - The Planning and Design and Parks and Natural Resources Divisions of the Department of Parks, Recreation, and Community Resources (PRCR) have identified a need for better education for staff about stream and riparian buffer maintenance;
 - The Department of Public Works (DPW) Engineering Division could also benefit from stream restoration training to improve the effectiveness of the Division's stream projects.

In addition, EPO plans to expand the information provided on its own Internet homepage to include much of the data presented in this Watershed Management Plan, including maps and photos, along with water-related educational and public outreach information.

Implementation Plan

Determining the current resources devoted to watershed management is difficult because there are multiple programs, multiple agencies, and these programs are often not traced as a separate activity. The best estimate is that, at this time, approximately seven FTEs are allocated in DES, DPW, and PRCR to programs like erosion and sediment control inspections, plan review, stormwater permit monitoring, BMP maintenance, and stormwater master planning activities. An estimated \$2.6 million annually funds programs like the existing street sweeping and litter control programs, storm sewer maintenance, and the Four Mile Run flood control channel maintenance program. This total also includes amounts programmed in the CIP for flood management projects, BMP retrofits, and storm sewer system rehabilitation.

The key recommendations in the Watershed Management Plan and Chesapeake Bay Preservation Ordinance Task Force Report can be grouped into the following principal recommendations:

- Expand street sweeping program;
- Increase inspections and plan review staff;

- Revise ChesBay Ordinance;
- Retrofit, build, and maintain stormwater facilities;
- Restore and maintain streams;
- Monitor streams regularly; and
- Educate and involve residents.

On average, these programs will require an additional \$1.2 million in annual operating and personnel expenditures and \$352,000 in additional CIP money each year.

Funding

Stream restoration and protection requires a long-term programmatic, as well as financial, commitment to Arlington's environment. The existing CIP program and the approximately \$350,000 in the Source Control Fund can be used to begin funding some of the proposed watershed management programs, including stream restoration and street sweeping. Changing the Source Control Fund formula may increase this source of funding in the future. However, the cost of the proposed programs exceeds existing resources. And, although there are a number of grants available from state and federal agencies, these funding sources, which will be explored where possible, cannot be relied upon as a long-term funding source.

There are other competing uses for the monies that fund the CIP and General Fund. The Watershed Management Plan and ChesBay Task Force both recommend that Arlington County seriously consider a dedicated, and potentially more equitable, funding source such as a stormwater utility to pay for stream restoration, BMPs, inspections and plan review staff, and other watershed management programs, as is done by a number of other Virginia jurisdictions.. The proposed implementation plan calls for a stormwater utility needs assessment and feasibility study to be conducted in FY 2002. The purpose of this study would be to determine if a stormwater utility could generate enough funds to cover both current and proposed expenditures for watershed management, replacing current CIP and General Fund sources for these activities.

Conclusion

Even today, after all the progress that has been made towards cleaning up the pollution from factories and wastewater treatment plants, the threats posed to streams by urban development and runoff remain one of the most difficult challenges facing local governments. The Watershed Management Plan provides a comprehensive framework for water resources management in Arlington County and helps us recognize that healthy urban streams are a key component of a sustainable community and a restored Chesapeake Bay. Even greater attention to "smart" growth management is critical if we are to successfully restore and protect our remaining streams and open spaces, not only for today's residents, but for future generations of Arlingtonians as well.

1 Introduction

Streams are an important recreational resource in Arlington as well as a part of the County's natural heritage. Arlington's stream valley parks such as Glencarlyn, Barcroft, Bluemont, Lubber Run, Long Branch, and Potomac Overlook are among the County's most attractive natural resources and most used recreational areas. In addition, the County spans the Piedmont/Coastal Plain transition zone known as the 'fall line'—characterized by geological features such as rocky outcrops and waterfalls. Metropolitan areas such as Washington and Baltimore are located where they are in part because of the fall line's historical significance as the limit of upstream navigation.

However, development in Arlington has significantly impacted the nearly 30 miles of perennial streams in the County. There were once many more miles of streams in Arlington until the steady development of the last 60 or 70 years put much of the stream network into underground pipes. Figure 1 shows the locations of existing and historical streams in the County.

Today, Arlington County is a highly urbanized jurisdiction, with 30-40 percent of the County covered by impervious surfaces such as streets, parking lots, and buildings that do not allow rain to soak into the soil. The more impervious area in a watershed, the more rainfall that becomes runoff in streams. This runoff often contains harmful pollutants, erodes streams, and damages habitat for fish, insects, and other stream organisms. In addition, this runoff absorbs heat from hot pavement and causes thermal pollution that can further harm many aquatic species.

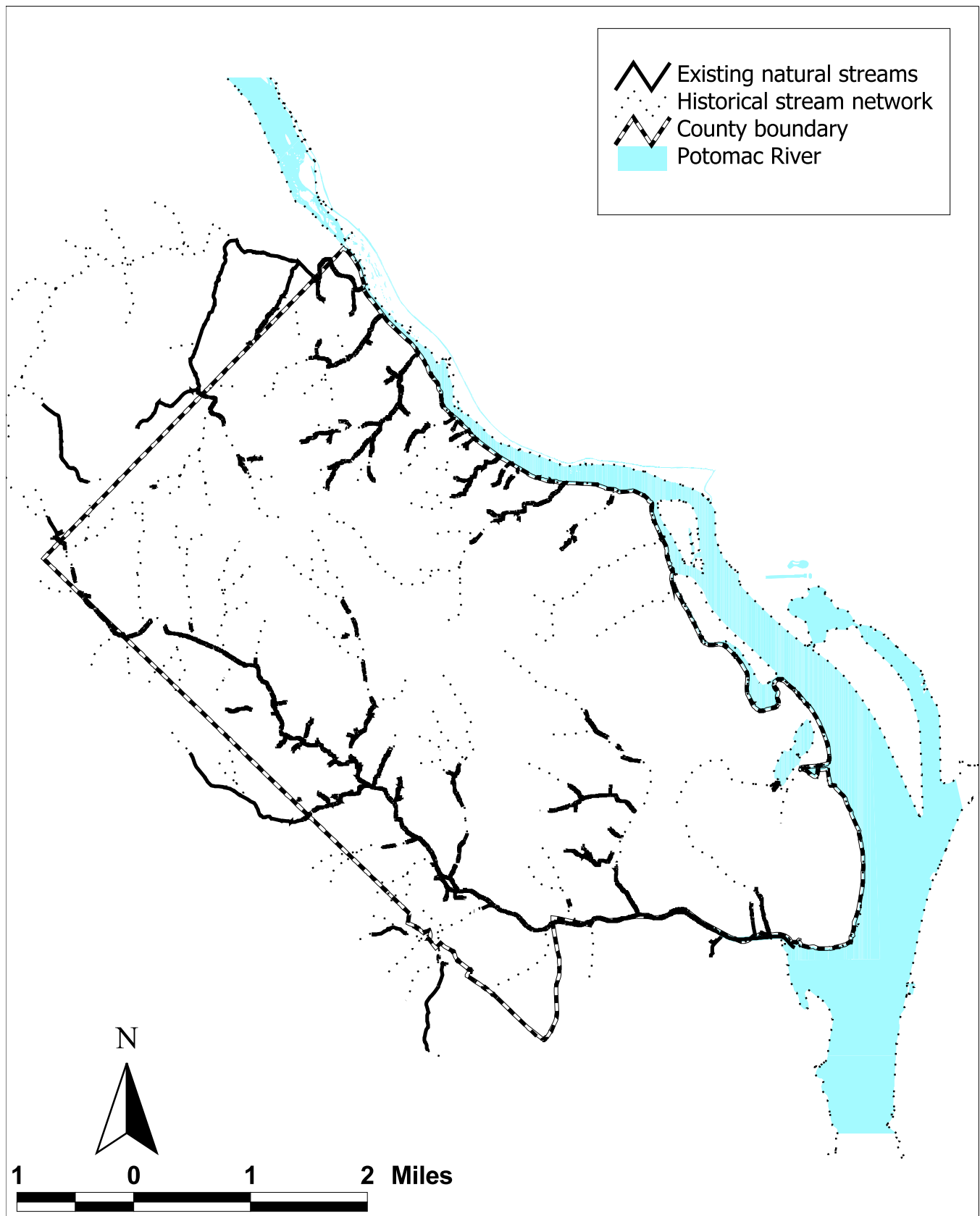
In general, stream degradation begins when imperviousness exceeds 10 percent, and significant deterioration occurs beyond 25 percent imperviousness (Caraco et al., 1998). Urban development and runoff are among the leading causes of water pollution in the U.S., and more than 20 percent of streams and rivers inventoried by states are impaired because of urban runoff and its effects on water quality and stream habitat (US EPA, 1996).

1.1 State and Federal requirements

To address the problem of urban runoff, the U.S. Environmental Protection Agency (EPA) issued municipal storm water regulations in 1992. These regulations require large municipalities, including Arlington County, to obtain and comply with National Pollutant Discharge Elimination System (NPDES) permits to discharge storm water. Arlington County's NPDES storm water permit (also known as a municipal separate storm sewer, or MS4, permit), issued through the state of Virginia in 1997, requires the County to monitor storm water runoff at representative outfalls and ***to demonstrate that the County has effective management practices in place to control urban storm water to the 'maximum extent practicable.'***

Over the next decade, EPA's Total Maximum Daily Load (TMDL) regulations will also affect Arlington County. The TMDL program requires states to determine the maximum pollutant loads that can be delivered to impaired waterbodies so that these rivers, lakes, and estuaries can meet water quality standards. Four Mile Run, which drains a large portion of Arlington County, will fall under this program because the stream does not meet water quality standards for fecal coliform bacteria. The development of TMDLs is a data and resource intensive process, and states and municipalities that begin to collect watershed information now—and start to reduce stream pollution—will be in a strong position to comply with these regulations.

Figure 1. Existing and historical streams in Arlington County.



1.2 Chesapeake Bay

On a regional level, the members of the Chesapeake Bay Program, which include Virginia, Maryland, the District of Columbia, Pennsylvania, and EPA, recently released 'Chesapeake 2000'—a document that renews the 1987 Chesapeake Bay Agreement to restore the bay. The primary goal of the new agreement is "to improve water quality sufficiently in order to sustain the living resources of the Chesapeake Bay and its tidal tributaries and to maintain that water quality into the future." (source: <http://www.chesapeakebay.net/pubs/C2Kintro.pdf>) One of the more specific goals of the new agreement is to improve water quality so that the bay and its tidal rivers will be removed from EPA's list of impaired waters by 2010.

1.3 Arlington County's role

Arlington County has an obligation to support regional efforts such as the Chesapeake Bay Program and is required by state and federal law to manage and protect its water resources. The County's historically central role in local water resource management and land use control must become an even stronger and more effective role. To date, the County's Chesapeake Bay Preservation Ordinance, Stormwater Detention Ordinance, and Erosion and Sediment Control Ordinance have been the primary tools to regulate the impacts of new development and redevelopment on County streams. However, the effects of existing development in a highly urban environment like Arlington County far outweigh the effects of new development or redevelopment. Therefore, the County has considerable work to do to achieve the 'maximum extent practicable' level of stormwater and water resource management to protect not only the County's streams but also the Potomac River and the Chesapeake Bay.

In recognition of the need for more effective and integrated water resource management, Arlington County's Department of Environmental Services (DES) Environmental Planning Office (EPO) applied for and received a grant from the Virginia Department of Environmental Quality (DEQ) in 1998 to develop a Watershed Management Plan for the County. This plan, developed in conjunction with the Department of Public Works (DPW), the Department of Parks, Recreation, and Community Resources (PRCR), and other County staff, with input from County residents and the County Board, will be an important tool for the County to:

- Determine baseline conditions in County streams;
- Comply with NPDES and TMDL regulations;
- Target funding from the County's Source Control Fund and Capital Improvement Program;
- Conduct watershed outreach and education; and
- Address the cumulative effects of development on Arlington's streams.

This watershed management plan is also an important complement to the Water Quality element of the County's Comprehensive Plan—a new element that will focus on the consistency of County ordinances and development policies that relate to the County's administration of its Chesapeake Bay Preservation Ordinance. Arlington County's Comprehensive Plan formally sets forth the policies for the County's future and serves as a guide for many public decisions including land use changes, preparation of capital improvements programs, and the enactment of zoning and related growth management legislation.

As a component of the Comprehensive Plan, the Water Quality element therefore will serve as an official guide for County implementation of the Chesapeake Bay Preservation Ordinance. The watershed management plan, on the other hand, will serve as a more comprehensive blueprint for local water resource management.

As such, this plan is not intended to provide detailed recommendations and schedules for specific projects. There are too many issues and entities involved, including funding, in implementing capital projects that are beyond the scope of this plan to resolve. Instead, the watershed management plan is ultimately a 'needs analysis' that identifies the County's water resource management responsibilities and lays out the effort needed above and beyond current practice to meet those responsibilities.

County residents have an important role to play in watershed management, too. Along with County management practices, the actions of citizens and business owners can have significant positive and negative impacts on streams—especially in an ultra-urban jurisdiction like Arlington County.

1.4 Components of the Watershed Management Plan

As specified in the DEQ grant, the broad objectives of the Watershed Management Plan include: i) developing a stream and riparian buffer inventory to identify restoration priorities; ii) providing an analysis of County management practices that affect streams and riparian buffers; iii) identifying strategies to protect and restore streams; iv) establishing a system to track development and stream and riparian buffer conditions; and, v) conducting a review of resources available for stream and watershed protection.

The Center for Watershed Protection (CWP), an innovative watershed restoration and protection organization, outlines discrete steps in the watershed planning process that are consistent with these objectives and therefore provide the framework for this Watershed Management Plan. These steps, modified for this plan, are:

- 1) Identify a watershed management entity;
- 2) Evaluate County water resource management practices;
- 3) Determine baseline watershed conditions;
- 4) Project future land use changes in the watershed;
- 5) Determine goals for the watershed;
- 6) Translate goals into action items for a watershed; and
- 7) Provide a plan for implementation.

(based on Caraco et al., 1998).

Fundamentally, the watershed management plan will evaluate the extent and type of existing and future development in a watershed and the condition of streams in the watershed. The plan will then identify feasible goals for the streams in a watershed which involve restoring streams (e.g., through bioengineering or improved buffer maintenance practices) and/or reducing the flow and improving the quality of storm water that reaches streams (e.g., through land use controls and Best Management Practices (BMPs)⁴ as well as through education).

1.5 Scale and scope of the Watershed Management Plan

All of the rain that falls on Arlington County eventually drains to the Potomac River. On a somewhat smaller scale, drainage in Arlington County flows either directly to the Potomac River or into two

⁴ Best Management Practices or BMPs are structural or nonstructural practices, or a combination of practices, designed to act as effective, practicable ways to minimize the impacts of development and human activity on water quality. Structural BMPs, which include extended detention dry ponds, wet ponds, infiltration trenches, sand filters, and in-line filters, rely heavily on gravitational settling and/or infiltration through a porous medium for pollutant removal. Nonstructural BMPs range from programs that increase public awareness to prevent pollution to vegetation-utilizing controls such as bioretention areas or wetlands (NVPDC, 1996).

tributaries of the Potomac—Four Mile Run and Pimmit Run. These scales, however, are too large for effective watershed planning (Caraco et al., 1998).

Therefore, this plan divides the County into 19 subwatersheds, which range in size from 0.3 square miles to 5 square miles, a scale that facilitates effective watershed assessment and management (Schueler, 1995). These subwatersheds are shown in Figure 2 and are also listed in Table 1, along with their impervious cover—an important determinant of stream quality in a watershed (Caraco et al., 1998). More than 20 years of urban storm water research indicates that impervious surfaces such as buildings and streets that prevent rain from soaking into the ground have a strong effect on stream conditions in a watershed (Schueler, 1995)

Impervious area has been calculated for each of Arlington's subwatersheds using a technique known as the Normalized Difference Vegetation Index (NDVI). The NDVI method uses the reflective characteristics of LANDSAT satellite imagery at 30 meter resolution to determine the percentage of each 30 meter pixel comprised of vegetative cover. The method then assumes that the remainder of the pixel area is comprised of impervious cover (Frost, 1995).

Table 1 also indicates that seven of these subwatersheds (identified by *) have drainage areas that extend beyond Arlington County borders. Areas outside the County were not analyzed for this plan. As a result, the plan will also need to include a mechanism to coordinate watershed management activities with Fairfax County, Falls Church, and Alexandria.

In particular, almost 90 percent of the 12.4 square mile Pimmit Run watershed, which includes the Little Pimmit Run subwatershed, is outside of Arlington County. The nine percent impervious figure in Table 1 is for a small portion of the Pimmit Run watershed along the George Washington Memorial Parkway. Given the mostly low-density residential land uses in this watershed as a whole, this impervious cover figure is most likely a considerable underestimate. Moreover, most of the Pimmit Run stream channel is located outside of Arlington County, and conditions in this portion of the stream channel are currently unknown. Because of the lack of information about the entire watershed, this plan does not provide management recommendations for Pimmit Run.

In contrast, although more than 80 percent of the Upper Long Branch subwatershed is outside of Arlington County, land uses in the portion of the subwatershed outside of Arlington appear similar to those within the County. As a result, the 25 percent impervious cover for the portion of this subwatershed within the County is probably indicative of the impervious cover for the subwatershed as a whole. Further, about one-third of the Upper Long Branch stream channel is within the County, and baseline conditions in this portion of the stream channel are known.

Similarly, the Lower, Middle, and Upper Four Mile Run subwatersheds have significant portions of their drainage outside the County. However, impervious cover estimates for the portion of these three subwatersheds within the County appear representative of the subwatersheds as a whole. And, the Four Mile Run mainstem stream channel is almost entirely within the County.

Although 43 percent of the Little Pimmit Run subwatershed is outside of the County, the upper drainage area is completely within Arlington. Therefore, the County has jurisdiction over the drainage area generating runoff that reaches the Little Pimmit Run stream channels within Arlington.

Impervious cover data are not currently available for the Potomac Direct (A) and Potomac Direct (B) subwatersheds. In addition, these subwatersheds both have a number of stream channels and drainage swales that reaches the Potomac—so, in fact, the Potomac Direct (A) and Potomac Direct (B) subwatersheds actually consist of several small and distinct drainage areas. These issues make it difficult

to assess current conditions in these subwatersheds as well as to manage runoff within them. Therefore, this plan does not provide an overall management strategy for these subwatersheds. Together, the Potomac Direct (A) and Potomac Direct (B) subwatersheds drain one square mile, or about three percent of the County. A significant portion of the land in both subwatersheds consists of the George Washington Memorial Parkway.

The National Airport, Cemetery/Pentagon, and Roaches Run subwatersheds do not contain any natural stream channels. In addition, much of the Cemetery/Pentagon subwatershed consists of the federally-owned Fort Myer, Arlington Cemetery, and Pentagon facilities, and the National Airport subwatershed, as the name suggests, consists of land managed by the Metropolitan Washington Airports Authority. As a result, this plan does not provide specific management recommendations for these subwatersheds.

Subwatershed	Drainage area (mi²)	Drainage area outside County (%)	Impervious (%)
Cemetery/Pentagon	1.9		31
Colonial Village, Rocky Run	1.2		58
Doctor's Branch	1.4		34
Donaldson Run	1.0		11
Four Mile Run, Lower Mainstem*	3.1	57	45
Four Mile Run, Middle Mainstem*	4.7	41	37
Four Mile Run, Upper Mainstem*	4.9	22	25
Gulf Branch	0.8		14
Little Pimmit Run*	2.8	43	23
Lower Long Branch	2.5		37
Lubber Run	1.6		37
National Airport	1.2		63
Pimmit Run*	1.1	89	9
Potomac Direct (A)	0.3		NA
Potomac Direct (B)*	0.7	20	NA
Roaches Run	1.1		61
Spout Run	1.8		39
Upper Long Branch*	1.3	81	25
Windy Run	0.5		21

Table 1. Total drainage area, drainage area outside Arlington County, and percent impervious cover for 19 subwatersheds.

Figure 2. Subwatersheds.



2 The Watershed Management Plan

2.1 Watershed management responsibility

Arlington County is required by state and federal law to manage and protect its water resources. The County therefore has a central role and expertise in, and responsibility for, local water resource management and land use control. In December 1999, DES, DPW, and PRCR formed a work group to analyze the results of the stream inventory and continue with the watershed planning process. This group developed this plan as a direct extension of the County's overall responsibility for watershed management and will serve as the primary entity for its implementation and revision.

However, County residents and the County Board will provide critical input into the development of this plan through an extensive public comment period. The role of the public will continue to be important during plan implementation as citizens identify problems and restoration opportunities within their subwatersheds and participate in stream monitoring and cleanups. Ultimately, the actions of County residents, along with business owners, can have a large impact, positive or negative, on streams—especially in an ultra-urban jurisdiction like Arlington County. In recognition of this fact, this plan emphasizes watershed education and pollution prevention as a key component. The phrase, "We all live upstream," is a profound message that all County residents, as well as County staff, must understand for this plan to be effective.

2.2 Existing County water resource and runoff management practices

The County has a variety of programs that address stormwater runoff and implements a considerable number of educational and pollution prevention initiatives. There are, however, significant gaps in County water resource management programs—gaps this watershed management plan identifies and makes recommendations to address. These include control of runoff from existing development, stream monitoring, and systematic, prioritized stream restoration. In addition, the regulations that govern new development and redevelopment in the County—the Storm Water Detention Ordinance, the Chesapeake Bay Preservation Ordinance, and the Erosion and Sediment Control Ordinance—have some shortcomings that are discussed later in this document.

The following sections highlight major County practices that address stormwater runoff and streams, covering five components that provide a logical framework for watershed management. These include:

1. Addressing the sources of stormwater runoff and dry weather pollution (existing and new development, point sources, illegal discharges);
2. Implementing and maintaining BMPs to control stormwater pollution;
3. Maintaining stormwater infrastructure;
4. Managing, restoring, and monitoring streams and buffers; and
5. Implementing pollution prevention and watershed education initiatives.

2.2.1 Sources of stormwater runoff and dry weather pollution

2.2.1.1 Existing development

Arlington County's NPDES stormwater or MS4 permit mandates that the County reduce stormwater pollution in all County subwatersheds. In particular, the 'maximum extent practicable' provisions of the permit, although not quantitative, require reductions in the concentrations of pollutants in stormwater samples collected. At this time, however, the County collects stormwater samples at four outfalls only—located in Little Pimmit Run, Colonial Village/Rocky Run, and Middle Four Mile Run. Therefore, the

scope of pollutant reductions that can be demonstrated through stormwater sampling is limited. In addition, the County has not yet implemented, and the state has not yet enforced, the 'maximum extent practicable' provisions of the permit (these provisions are discussed further in Section 2.6, 'Watershed management recommendations'). However, the County's MS4 permit will be renewed every five years. The first renewal will occur in 2002. This is a likely timeframe for the state to include new monitoring or management requirements in the County's permit.

2.2.1.2 New Development and Redevelopment

The County's Chesapeake Bay Preservation Ordinance, Stormwater Detention Ordinance, and Erosion and Sediment Control Ordinance provide legal authority to minimize increases in stormwater runoff and pollution before development or redevelopment occur. The Storm Water Detention Ordinance requires that the peak runoff rate from new development and redevelopment be maintained close to predevelopment levels, unless a waiver is granted. Arlington County first enacted the ordinance in 1976 in response to the Four Mile Run flood control agreement with the U.S. Army Corps of Engineers (USACOE). This agreement, which also includes the cities of Alexandria and Falls Church and Fairfax County, created a program to prevent new development in the Four Mile Run watershed from increasing storm water runoff to the extent that it might reduce the effectiveness of the USACOE flood control project in the lower reaches of Four Mile Run to adequately contain runoff from the 100-year storm⁵.

Under the Stormwater Detention ordinance, for the Four Mile Run watershed, stormwater detention must be provided for the 100-year flood from the developed site and released at a rate equivalent to a 10-year flood from the site in its pre-developed condition. For the Potomac watershed, stormwater detention must be provided for the 10-year flood from the developed site and released at a rate equivalent to a 10-year flood from the site in its pre-developed condition. Release at the 10-year flood runoff rate was chosen because public sewers are designed to convey this magnitude event.

Depending on the size and level of impervious cover on a proposed site and its proximity to a stream channel, new development/redevelopment may also be subject to the County's Chesapeake Bay Preservation Ordinance, and storm water quality controls may be required in addition to stormwater detention.

In addition, the County's Floodplain Management Ordinance ensures compliance with the National Flood Insurance Program by i) defining and establishing the floodplain district, including areas subject to the 100-year flood; ii) describing uses permitted and banned in the floodplain district; iii) setting out flood damage control and floodproofing requirements for new construction in the floodplain district; and iv) defining the information needed from a building permit and development plan for construction in the floodplain district (Arlington County DPW, 1996).

DPW's Engineering Division reviews development plans for compliance with these ordinances. Under the Chesapeake Bay Ordinance, most developers contribute to the Source Control Fund—a fund

⁵ For any given storm event duration (e.g., 1 hour, 6 hours, 24 hours), a 1-year storm event has a 100 percent chance of occurring in any given year, a 2-year storm event has a 50 percent chance of occurring in any given year, a 10-year storm event has a 10 percent chance of occurring in any given year, a 100-year storm event has a 1 percent chance of occurring in any given year, etc. The frequency of these events is referred to as a 'recurrence interval' and, for a given region, is estimated by a statistical analysis of the historical record of storm events of a given duration. Because a historical record of the magnitude of runoff events is not available for most small stream channels, stormwater engineers make the assumption that the runoff produced by a given storm event (simulated as a worst-case 'design storm') has the same recurrence interval as the storm event itself. For small, impervious drainage areas such as a street or subdivision, this assumption is reasonable. The duration of the design storm is equal to the 'time of concentration' of the drainage area—the time required for flow to reach the drainage area outlet from the hydraulically most distant part of the drainage area (Dunne and Leopold, 1978).

established under Section 61-9 of the ordinance which is to be used for water quality improvements and watershed education. The intent of allowing this contribution is to minimize the proliferation of small BMPs which can be difficult to inspect and maintain.

However, if stormwater issues are raised early enough in the site plan review process, developers have shown a willingness to look more closely at providing water quality BMPs. The involvement of the DES' Environmental Planning Office (EPO) earlier in the process (e.g., at the development proposal stage) could provide more opportunities to encourage water quality protection (BMPs, etc.) as one condition for granting a building permit. There are limits, however, to what the County can require beyond ordinance requirements because of by-right development. Currently, the County does encourage some water quality protection site design measures before approving a Source Control Fund contribution.

For FY 1999, DPW reviewed approximately 70 building permit applications for projects that will disturb greater than 2,500 square feet of land—the threshold that triggers a water quality impact assessment under the ordinance within a Resource Protection Area. About one-third of these proposed projects met the criteria that require controls to offset potential water quality impacts. If these projects are approved, the developers for these projects must contribute approximately \$145,000 to the Source Control Fund. No onsite BMPs will be constructed. The proposed impervious surface of these projects totals approximately 120 acres or about 0.2 square miles. In total, developers contributed more than \$43,000 to the Source Control Fund in FY 1999. The total fund balance at the end of FY 1999 was approximately \$230,000. (Arlington County DES, 1999) The fund's current balance is close to \$340,000.

DPW usually grants waivers under the Storm Water Detention ordinance for sites with post-development peak flow increases of less than one cubic foot per second (cfs). Currently, the County has no mechanism to consider the cumulative impacts of granting such waivers because the ordinance requires the County to review waiver requests on case-by-case basis only. However, with County funding, NVRC models the effect on channel capacity of increased flows from all development in the Four Mile Run watershed under the Four Mile Run flood control agreement. In addition, this watershed management plan proposes a system to track development projects on a subwatershed scale to attempt to account for the cumulative effects of development in the County on streams and buffers.

DPW and the Department of Community Planning, Housing and Development (CPHD) share in the management of the Erosion and Sediment (E&S) Control Program for Arlington County. There are three inspectors, one plan reviewer, and one program administrator that work in the program and have been certified by the Virginia Department of Conservation and Recreation. In addition, two certified professional engineers assist with plan review.

There were no stop-work orders issued as a result of erosion and sediment control violations in FY 1999, during which a total of 84.91 acres was disturbed for 43 developments, single family lots, and school projects. However, violations of the E&S ordinance are common (for example, EPO staff observed violations at three different construction sites on one day in November 1999) and, because of limited staff, inspections cannot occur frequently. In FY 2000, DPW hired another staff person to act as an erosion control specialist to be in charge of compliance, make spot inspections, and deal with problem sites (Arlington County DES, 1999).

DPW's Planning Division coordinates plan review, including storm water detention and erosion and sediment control, within DPW for larger development projects (single family development goes directly to DPW Engineering and then to Building Permits). This department is also involved with the construction phase after a building permit is granted.

2.2.1.3 Point sources

According to information contained in EPA's Permit Compliance System, there are three NPDES-permitted point sources in Arlington County subwatersheds: Concrete Supply & Service Corp. in Upper Four Mile Run; Falcon Concrete in Roaches Run; and the County's Water Pollution Control Plant (WPCP) in Lower Four Mile Run. Discharges from these facilities are required to meet specific effluent standards.

The Arlington WPCP is the major permitted point source discharger in Arlington County. The plant discharges treated wastewater to Four Mile Run about one mile upstream from its confluence with the Potomac River. The plant is currently being expanded to accommodate average daily sanitary sewage flows of 40 million gallons per day.

The plant is an advanced wastewater treatment facility that includes primary treatment that screens and settles out organic material and other solids. Secondary treatment is also provided that biologically breaks down the organic waste to reduce pollutants, and tertiary treatment that uses chemicals and activated carbon to reduce nutrients like phosphorus to very low levels. The sludge produced as a result of the various treatment processes is currently treated with lime to produce a biosolid that is land applied on agricultural land, or is landfilled when weather conditions make land application sites inaccessible.

As part of the current upgrade, the facility is also adding a new technology called Biological Nutrient Reduction (BNR). This technology reduces the levels of nitrogen compounds, like ammonia, in the effluent. This is important because ammonia is toxic to aquatic life at higher concentrations and also breaks down into nitrites and nitrates that contribute to the nutrient problem in the Chesapeake Bay.

In addition, the plant is adding a large holding tank that will help the plant significantly reduce the wet weather bypasses⁶ that have occurred in the past. These bypasses are caused by hydraulic overloading of the plant, which is a direct result of the County's early plumbing code, which allowed roof drains and areaway drains to be connected to the sanitary sewer system. Although the building code was amended in 1968 to prevent these types of connections, the cost to disconnect many existing homes with such connections is cost-prohibitive. DPW does have an active infiltration/inflow program which works to identify, quantify, and repair leaks in sanitary sewers, and to replace or re-line sewers that are failing (see Section 2.2.3, 'Stormwater infrastructure'). Such lines allow groundwater into the sanitary sewer system and contribute to the hydraulic overloading at the plant. The new holding tank is currently under construction, and is expected to be operational by mid-2001.

Finally, before being discharged the treated wastewater undergoes chlorination to eliminate fecal coliform bacteria and other pathogens. The final effluent is then dechlorinated to prevent adverse impacts on aquatic life in Four Mile Run.

Because the WPCP is a major discharger, it is useful to put its contribution of nutrients in perspective. The following information is taken from the Virginia Secretary of Natural Resources report entitled, "1999 Annual Report on the Development and Implementation of Nutrient Reduction Strategies for Virginia's Tributaries to the Chesapeake Bay" (November 1999).

⁶ Most wet weather bypasses—with the exception of extreme storms such as Hurricane Floyd—involve releases of partially treated waste water, not "raw sewage." Partially treated waste water typically has been through two or more stages of treatment, and its potential environmental and health effects are significantly less than that of untreated waste water. Also, when partially treated waste water is released to Four Mile Run during large storms, the high flows in the stream dilute the release. The Virginia Department of Environmental Quality (DEQ) is always notified when discharges of wastewater occur, regardless of the reason for the discharge.

According to this report, there are 34 permitted point source dischargers located in Virginia's portion of the Potomac River Basin (including the Shenandoah River). Most of these point source dischargers are wastewater treatment plants, but there are several industrial dischargers like Merck (pharmaceuticals) and Dupont (chemicals), as well as several food processing industries that discharge treated wastewater to the Potomac River or one of its tributaries.

Figure 3 shows the relative contributions of phosphorus from these point source dischargers. The figure compares the total 1998 phosphorus discharge of 539,111 pounds per year, with a phosphorus discharge of 678,481 pounds per year in 1985. Northern Virginia point sources are highlighted in the figure, and it can be seen that together they contributed approximately ten percent of the point source phosphorus discharge in 1998, while 90 percent of the phosphorus is discharged by other point sources in the basin. The figure also shows that Arlington's contribution of phosphorus dropped from 6.9 percent of the basinwide total in 1985, to approximately 1.2 percent in 1998. Arlington is the 20th largest of the 34 point sources of phosphorus, discharging 6,669 pounds per year to Four Mile Run.

As seen in Figure 4, between 1985 and 1998, Arlington County's phosphorus discharge dropped by over 40,000 pounds per year. With the exception of Virginia's contribution to the Blue Plains Wastewater Treatment Plant in the District of Columbia, there was actually a decline in phosphorus loads throughout the basin, with Arlington County ahead of other jurisdictions in Northern Virginia by a substantial margin. In terms of percentage change, Arlington County actually reduced its phosphorus discharge by almost 86 percent, which was ahead of all other jurisdictions. The net overall reduction in phosphorus throughout the basin equaled 20.5 percent between 1985 and 1998, due primarily to improved wastewater treatment technology and more stringent phosphorus discharge limits.

The second important nutrient that affects the Chesapeake Bay is nitrogen. Here, the basinwide story is less encouraging, although Arlington County's nitrogen discharges have fallen dramatically. Figure 5 compares the point source nitrogen loadings in the Potomac River Basin between 1985 and 1998. It can be seen that the total point source nitrogen loads actually increased from approximately 10.7 million pounds per year to 11.2 million pounds per year.

Arlington County's contribution dropped from 15.4 percent to 8.1 percent of the basinwide total over this period. However, it is important to recognize that Arlington County ranked as the fourth largest point source discharger of nitrogen, delivering 912,736 pounds of nitrogen to Four Mile Run. Also apparent from the figure is that in 1998, Northern Virginia dischargers accounted for approximately 79 percent of the nitrogen discharges, with the remainder of the basin accounting for 21 percent of the total, reflecting the concentration of population in Northern Virginia.

Arlington County, on the other hand, has made considerable progress in reducing its nitrogen discharge. Figure 6 shows that between 1985 and 1998, Arlington reduced its nitrogen load by 728,545 pounds per year, or over 44 percent. This is significant, because it means that Arlington County was the only jurisdiction in Northern Virginia that actually met the Chesapeake Bay Tributary Strategy goal of a 40 percent reduction for both phosphorus and nitrogen. And with the introduction of Phase I of the new BNR technology scheduled for completion by 2002, the WPCP will reduce its nitrogen levels even further in the future.

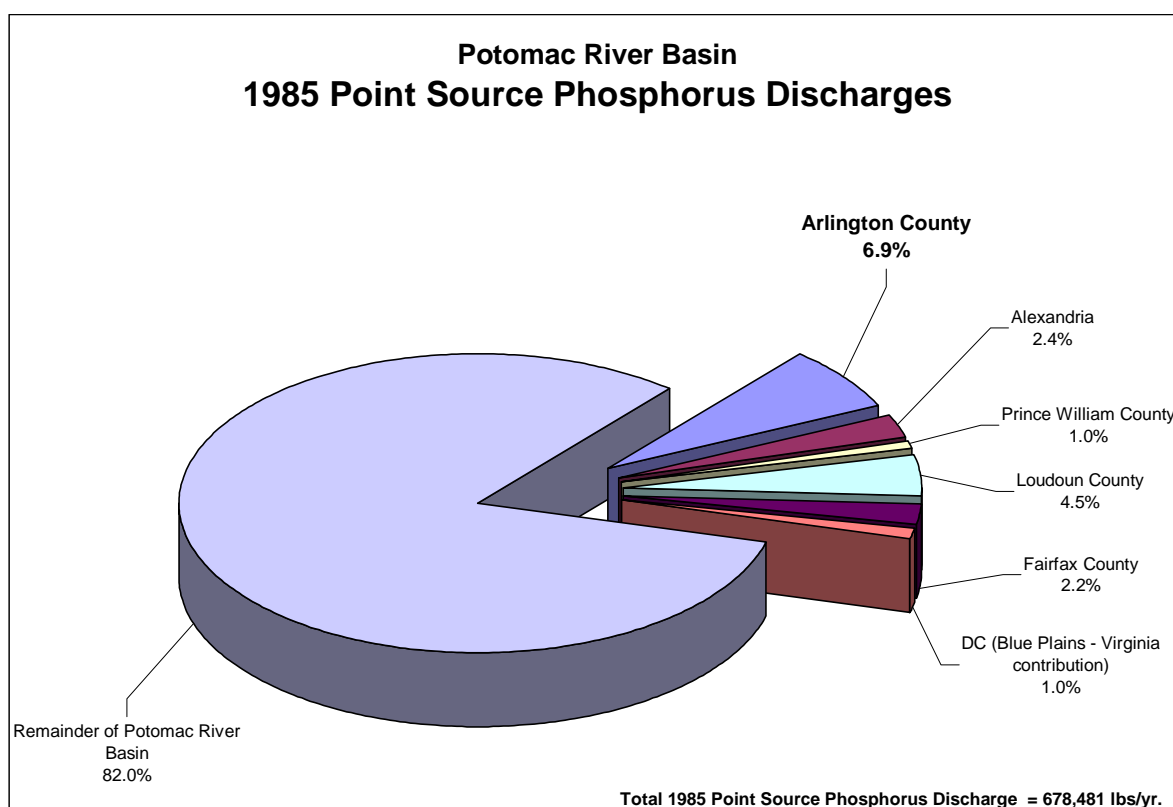
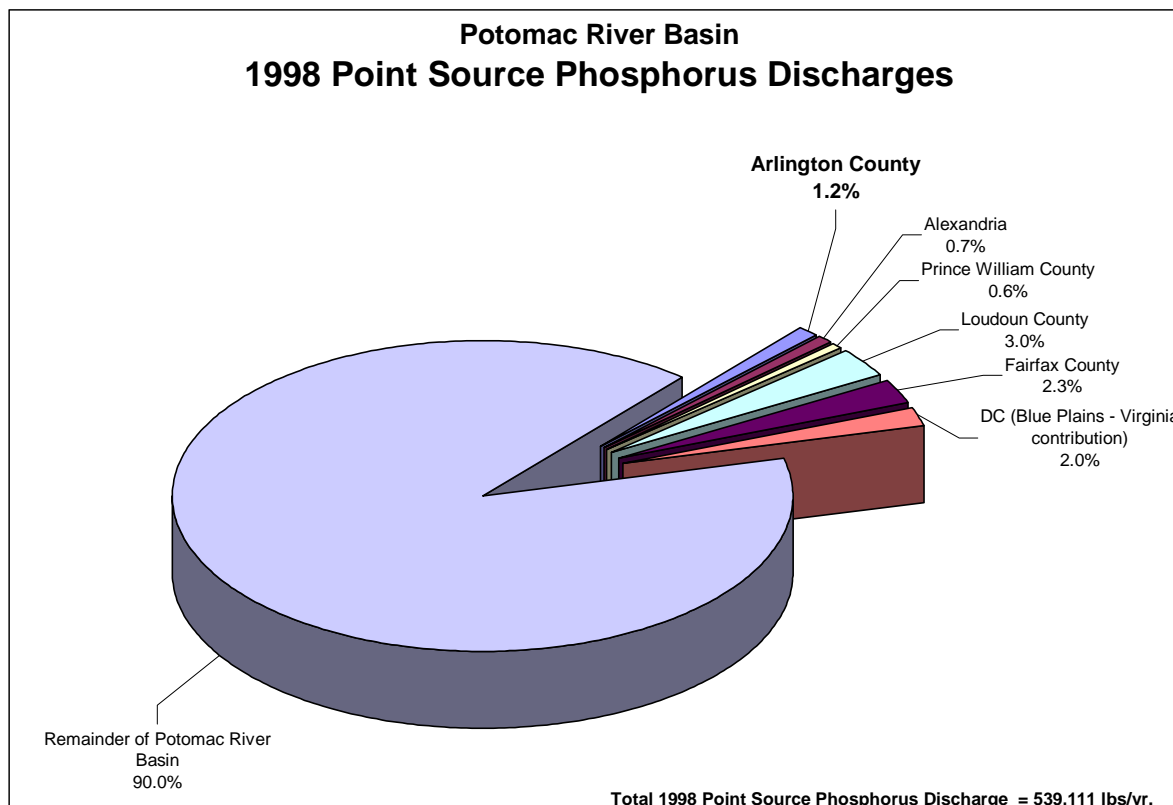


Figure 3. Point source discharges of phosphorus in the Potomac River Basin, 1985 vs. 1998.

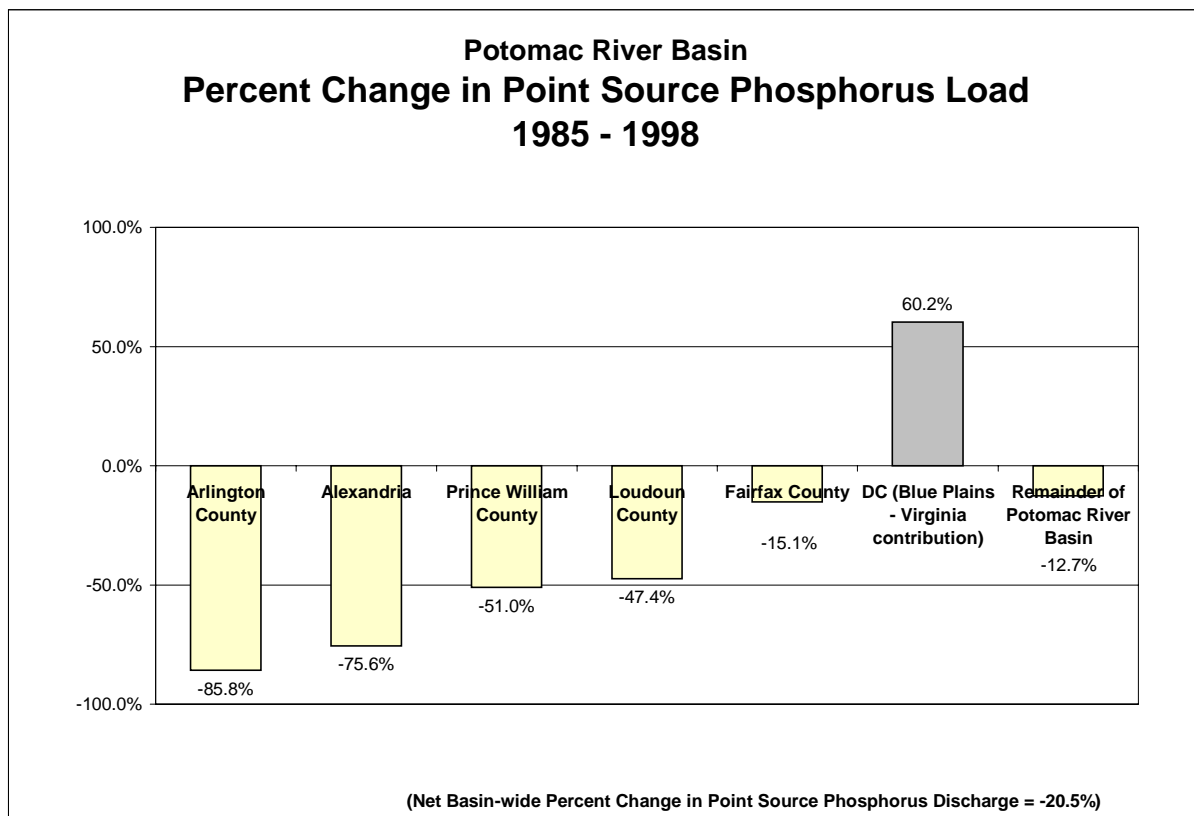
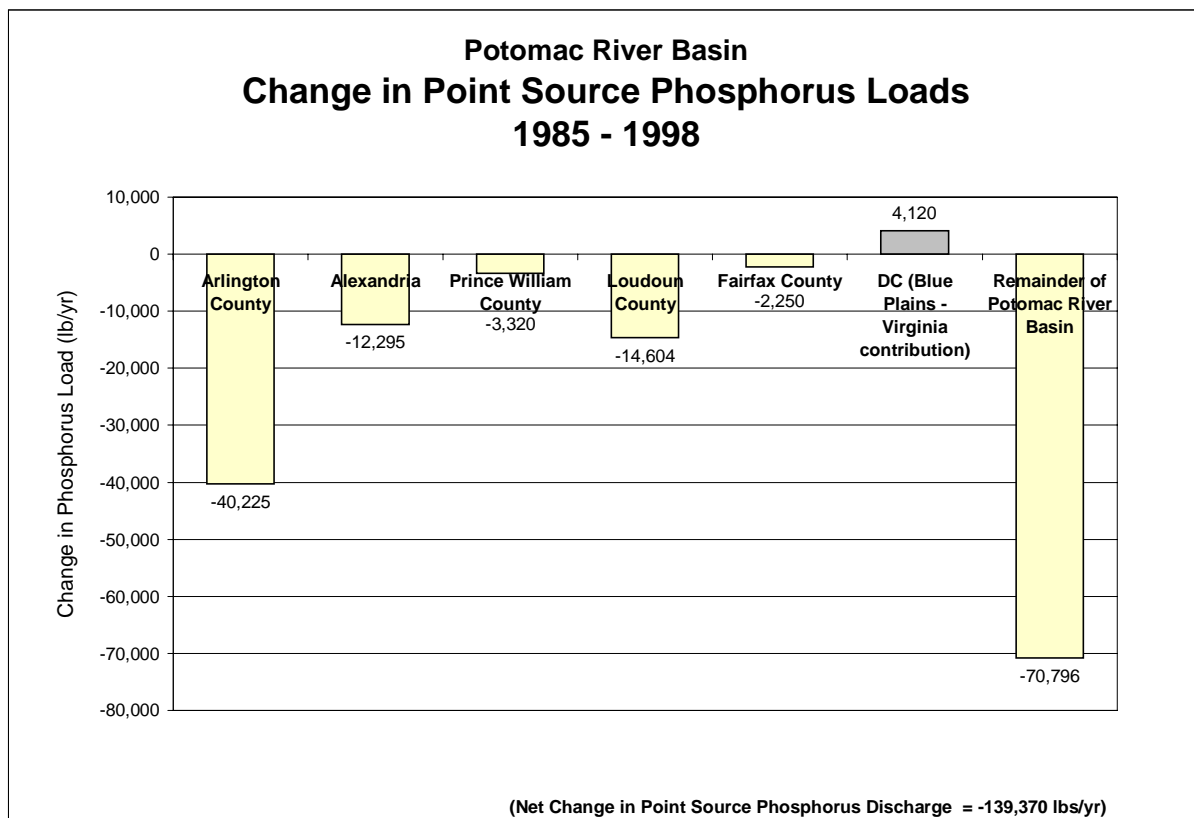


Figure 4. Change in point source phosphorus loads in the Potomac River Basin, 1985-1998.

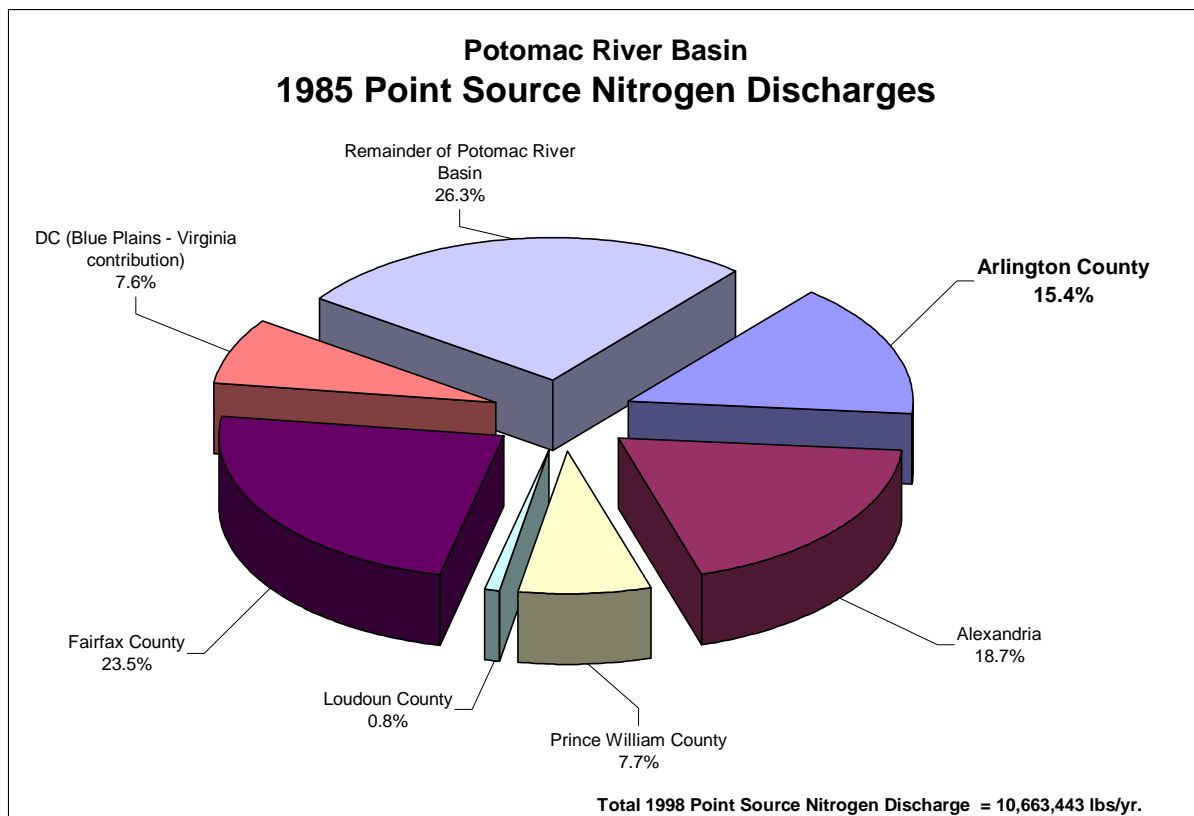
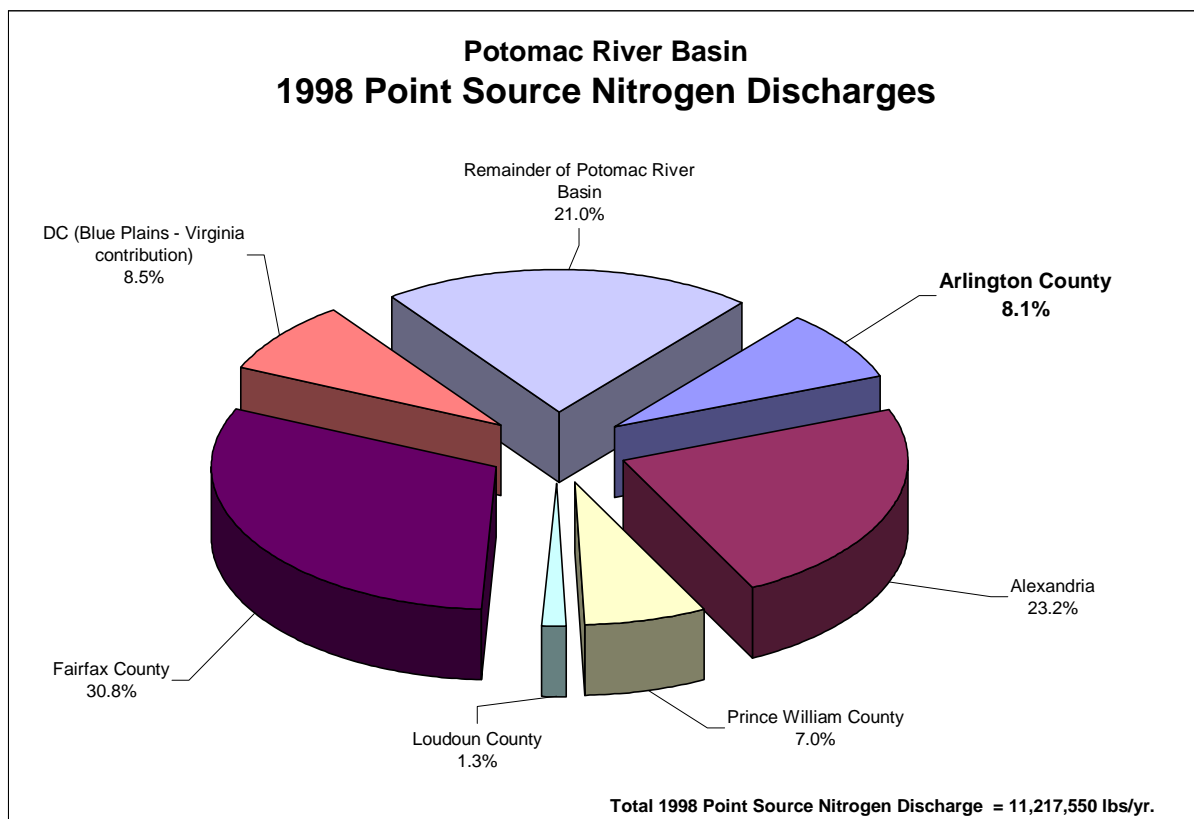


Figure 5. Point source discharges of nitrogen in the Potomac River Basin, 1985 vs. 1998.

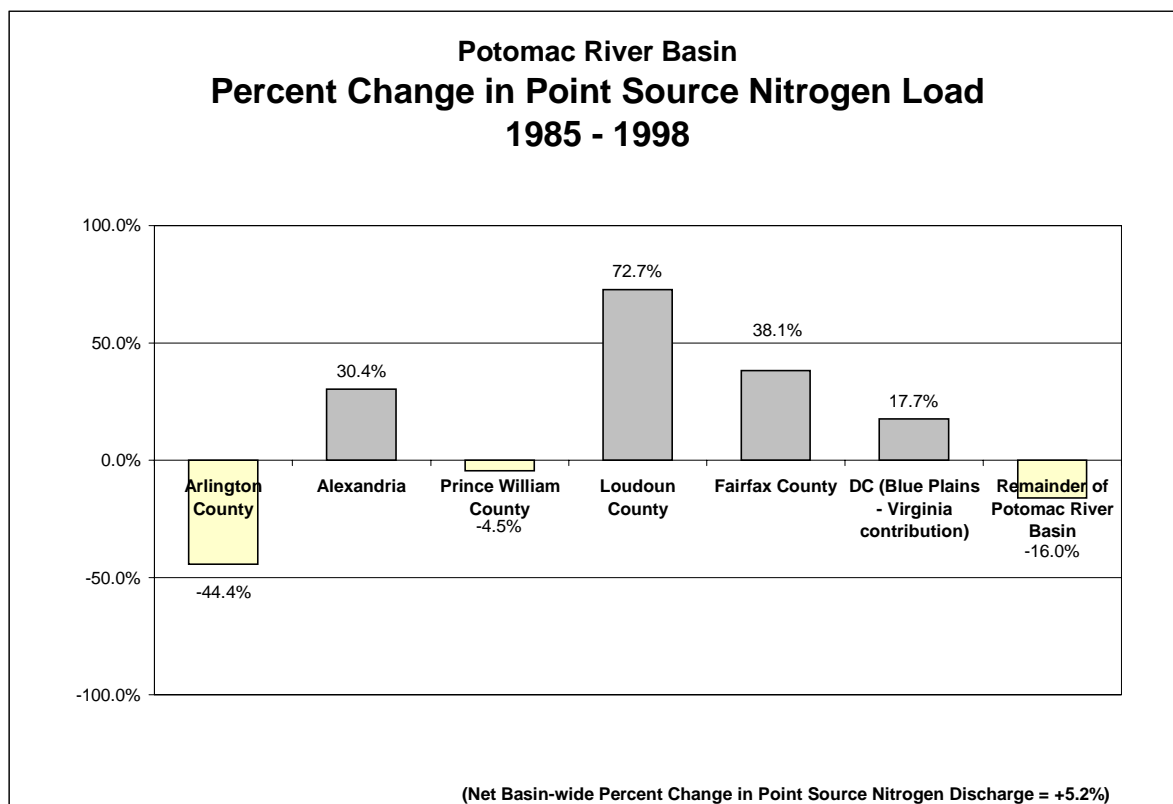
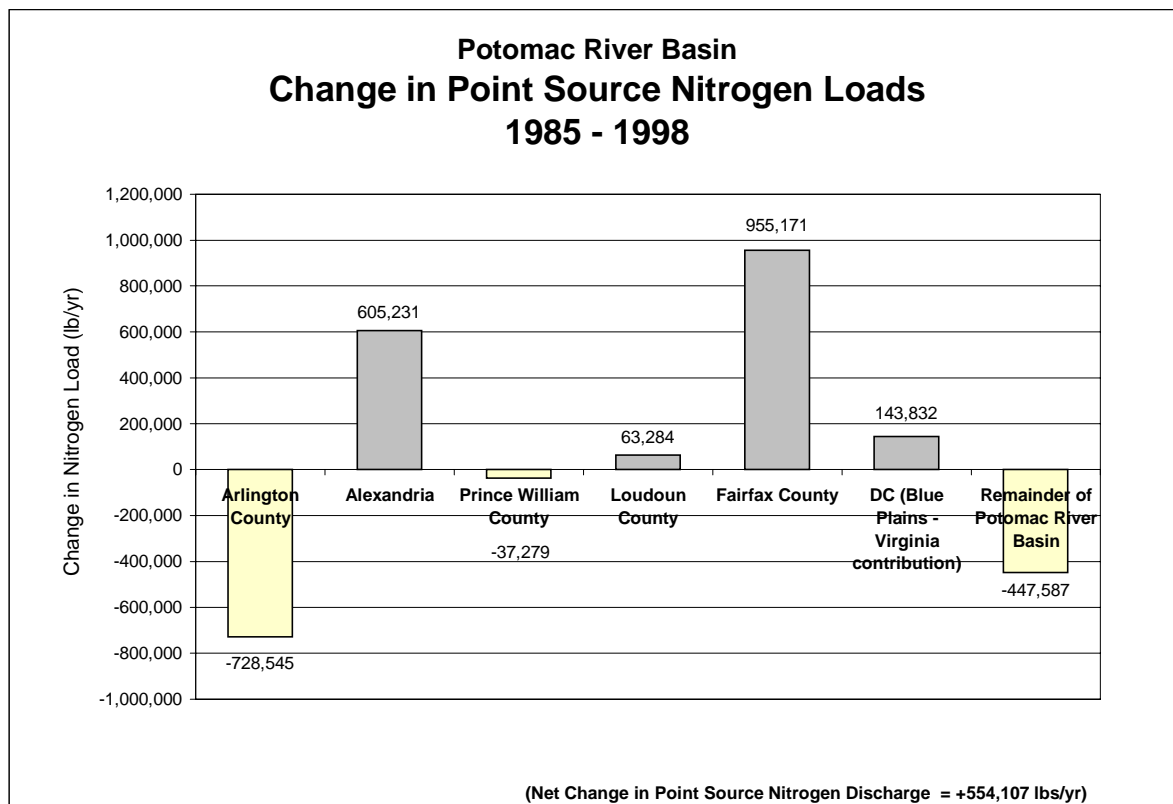


Figure 6. Change in point source nitrogen loads in the Potomac River Basin, 1985-1998.

2.2.1.4 Dry weather pollution

The County's MS4 permit also requires annual dry weather inspections for illicit non-stormwater discharges at major outfalls in all the subwatersheds identified in this plan. Each year, the County analyzes samples collected from one-fifth of these outfalls for major indicators of illicit connections. Dry weather inspections during FY 1999 discovered a cross-connection to a storm sewer in Bluemont Park from a Fairfax County apartment building. The connection had existed since the apartment building's construction 27 years ago.

Annually, DES visually inspects each major outfall (greater than 36 inches in diameter) for flow, odor, color, clarity, floatables, stains, and algae. In addition, each year, the County tests one-fifth of the outfalls for temperature, pH, chlorine, copper, phenols, and surfactants, using a Hach colorimeter kit.

To date, odor, color, and clarity have been the three most effective indicators of contamination. In Arlington's urbanized watersheds, floatables such as garbage, foam, and scum are found frequently in discharges that appear clean otherwise. Stains do not usually indicate any dry weather contamination. Vegetation and pipe condition tend to be essentially normal everywhere. Where vegetation is excessive, it is usually above the outfall caused by ambient conditions such as light. Algae is found frequently, and orange iron oxidizing bacteria/algae are common. Other varieties probably indicate excessive nutrients, a problem County-wide.

Follow-up procedures will focus on two chronic sources of illicit discharges under the County's direct control: sanitary sewers and water mains. This approach also addresses the County's concern with levels of pathogens reported in its streams, and will allow Arlington to focus its resources on finding and removing the sources (Arlington County DES, 1999).

In addition, County funds help support NVRC's optical brightener outfall monitoring project—a low-tech approach to detecting illicit discharges into the storm sewer network in the Four Mile Run watershed by looking for evidence of optical brighteners in dry weather flows. Optical brighteners are added to laundry detergent sold in the U.S. to make light colors appear brighter without the use of bleach. Since laundry effluent is a major component of human sewage, and since optical brighteners decompose very slowly, these brighteners serve as good indicators of the presence of wastewater in storm drains (NVRC, 2000). Using this method, NVRC screened 187 outfalls in a 10-square mile area of Four Mile Run during the summer of 1999. One of these outfalls contained consistently elevated levels of laundry brighteners. NVRC reported the results from this outfall, located within Fairfax County near Seven Corners, to appropriate Fairfax County staff. Results for many of the 187 outfalls monitored were inconclusive. If optical brighteners were present at these inconclusive outfalls, they were in moderate-to-minor concentrations only (NVRC, 2000; Waye, 2000).

2.2.1.5 Septic Tanks

EPO has identified approximately 75 residential parcels throughout the County that use septic tanks, rather than being connected to the County's sanitary sewer collection system, as shown in Figure 7. Although septic tanks are found throughout the County, most of these properties are concentrated in the Palisades area in the northeastern portion of the County. The steep topography in this area makes it expensive to serve these areas with sanitary sewer lines. In most cases, a force main and pumping station would be required to lift the sewage up to connect with the rest of the sanitary sewer system, which is a gravity flow system.

The County's Department of Human Services—Environmental Health Division (EHD) issues septic tank permits under Virginia state law. EHD conducts soil evaluations and issues construction permits for on site sewage disposal systems, which include septic tanks as well as alternative systems.

Septic tanks rely on natural decomposition of solids in a large holding tank to reduce the volume of waste. Solids sink to the bottom of the tank where they accumulate and periodically must be pumped out. The liquid waste flows out into an underground drainage field, where soil bacteria are supposed to break down the remaining dissolved nutrients and organic matter in the drainage field. Although there have been some improvements in the efficiency of advanced septic systems (e.g., mound systems, recirculating sand filters, etc.), the conventional septic tank serving a single residence is not considered a very effective method of waste treatment from a water quality perspective.

Performance of septic systems is very dependent on the organic loading to the drain field, the percolation rate of the soils, and the distance to the groundwater table. The natural bacterial breakdown of waste in the septic tank or in the drainfield can also be seriously disrupted by the disposal of various household products into the septic system, including solvents and cleaners.

Numerous studies from around the country have raised environmental concerns about septic tanks. Septic tanks do not eliminate bacteria or other pathogens, and soil bacteria do not effectively metabolize all of the dissolved constituents. This is particularly true for nutrients like nitrates and nitrites. For example, studies in Door County, Wisconsin, identified septic tanks as a primary cause of nitrate-contaminated groundwater, as well as a higher than normal frequency of gastrointestinal illnesses. This problem was especially serious where soils were thin, the underlying bedrock geology was highly porous or fractured, and many of the vacation homes in this area relied on shallow wells for their water supply (Sherrill, 1978).

Bacterial contamination of shellfish beds has also been traced to leaking septic systems, particularly in estuaries like the Chesapeake Bay and in Florida. According to an article by Bill Matuzeski, Director of EPA's Chesapeake Bay Program, in the *Bay Journal* (Vol. 7, No. 1, March 1997), roughly one quarter of all residents in the Chesapeake Bay watershed rely on septic tanks for their domestic waste disposal, or approximately 3.3 million people.

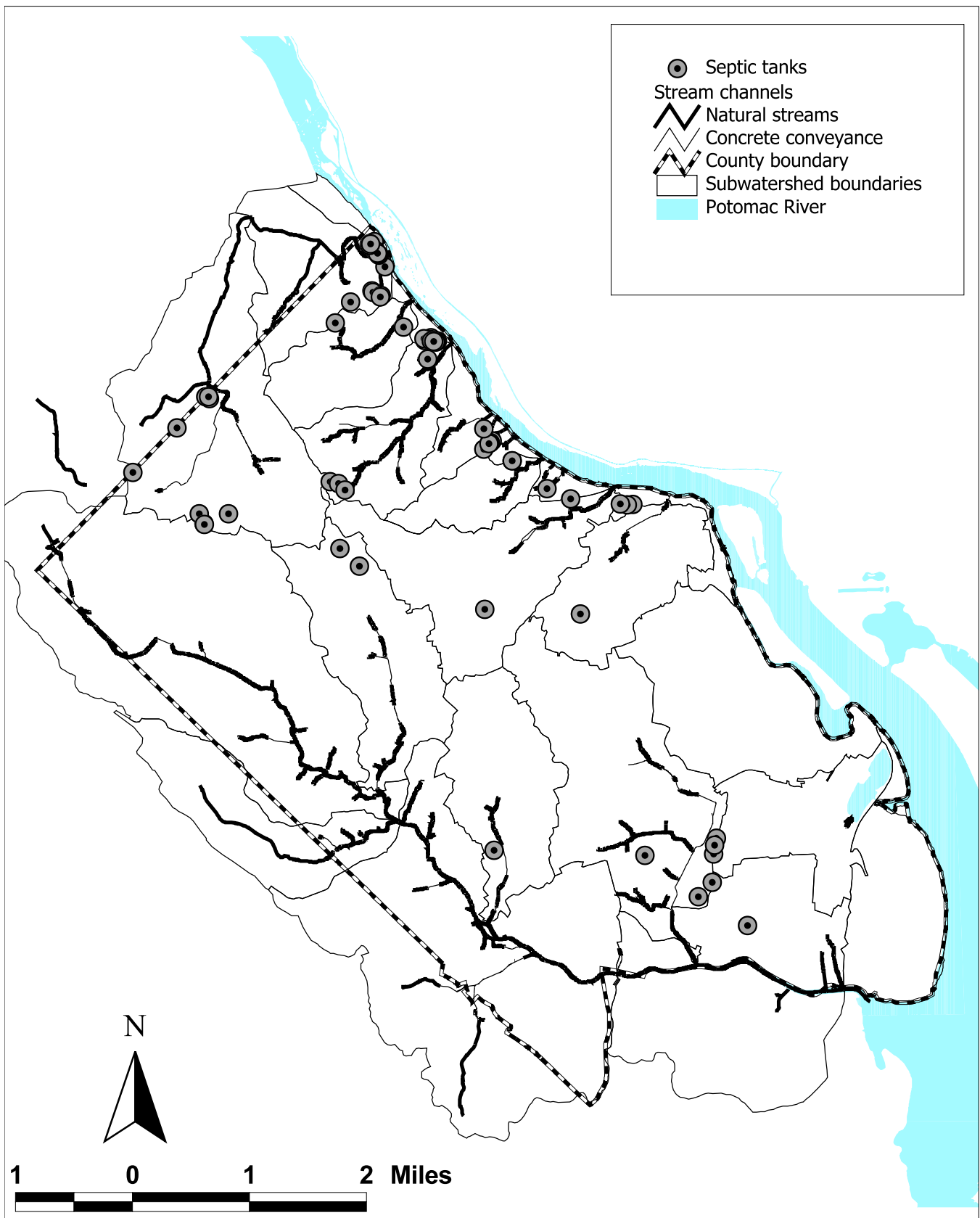
The article goes on to state that a properly operating septic system has been shown to release more than 10 pounds of nitrogen per year to the groundwater for each person using it. Using the County's average of 2.12 persons per household, the existing 75 Arlington households served by septic systems could be releasing as much as 1,590 pounds of nitrogen per year to the groundwater.

Although such individual contributions may seem minimal, the overall impact on the Bay is enormous. For example, the 3.3 million people on septic tanks in the Bay watershed generate 33.5 million pounds of nitrogen loaded into the groundwater each year. Of this, an estimated 13.4 million pounds reach open water, and about 9 million pounds of nitrogen reach the Bay.

This source of nitrogen is not insignificant. The Bay Program's 40 percent nitrogen reduction goal is 74 million pounds per year. This means that existing septic systems are delivering one-eighth of the pounds of nitrogen that are needed to meet the goal.

Fortunately, Arlington County gets its drinking water supply from the Potomac River and does not rely on groundwater. This significantly reduces the possibility of adverse public health impacts from septic tanks in residential areas. Nevertheless, septic tanks may contribute to local water quality problems because they contribute nutrients, and possibly bacteria or viral pathogens to groundwater. This could be a source of pollution affecting water quality in areas that have higher concentrations of septic systems, especially during baseflow conditions when most of the water flowing in County streams consists of groundwater.

Figure 7. Septic Tanks in Arlington County.



2.2.1.6 Spill response

The Northern Virginia Regional Hazardous Materials Response Team is comprised of team members from Arlington and Alexandria and responds to calls from Arlington, Alexandria, Falls Church and Fairfax. A team of four firefighters, two paramedics and one police support unit responds to possible hazardous material spills and discharges. Backup teams are called to the site if full containment is required. The Arlington County Department of Public Works assists in clean up and investigation as needed.

There were approximately 540 calls to the Fire Department in FY 1999 regarding unknown substances that involved an odor, material spill, or discharge. Of these calls, 7-10 per month normally require investigation and possible enforcement by the Fire Marshal. The party responsible for an illegal discharge can be fined up to \$2500 and the cost of clean up.

The Department of Environmental Services, the Fire Marshal's office and the Department of Public Works hope to develop a pollution response tracking system, which would be a component of the larger watershed tracking system discussed in this plan.

Citizens or staff suspecting stream pollution should adhere to the following hierarchy for the most effective County response:

- Active or on-going spills or dumpings of any kind should be reported to the Arlington County Emergency Communications Center (ECC) to either the non-emergency number (558-2222) or to 911. An engine company and/or a Hazardous Materials Team will be sent to investigate immediately.
- If the spill or dumping is no longer taking place and does not appear to be a significant threat to the environment or human safety, it should be reported to the Fire Prevention Division's main line (228-4644). A Deputy Fire Marshall will then investigate the complaint, normally within 24 hours.
- A suspected sewer leak or break in a sewer line, should be reported immediately to the DPW Water, Sewer, Streets Division at 228-6485 (7 AM - 4 PM) or 228-6555 (after hours). A foul sewage odor, white cloudy water, or floating organic material typically characterizes sewer leaks.
- DPW Water, Sewer, & Streets Division will report all confirmed sanitary sewer leaks into Arlington streams and storm sewers to the Virginia DEQ within 24 hours.
- DPW will also report confirmed sanitary sewer leaks to Jason Papacosma, DES Environmental Planning Office, 228-3613 (8 AM - 5 PM or voicemail), within 24 hours. This information is needed to satisfy a reporting requirement of the County's stormwater permit.

2.2.2 Stormwater BMPs, BMP retrofits⁷, and maintenance

2.2.2.1 Structural controls

Arlington County owns very few major structural BMPs for storm water management. However, the County has reserved funds in the Capital Improvement Plan (CIP) to construct BMPs identified through the planning process (see Section 2.8, 'Implementation plan').

In FY 1999, Arlington County developed plans to restore Sparrow Pond, a constructed wetland at the outlet of Arlington Forest Branch in the Middle Four Mile Run subwatershed, using CIP funds. This work is scheduled to begin in FY 2000. In FY 1999, the Army-Navy Country Club (ANCC) approached County staff to study three possible sites where the Club would donate land in return for construction of a pond to help reduce downstream erosion. The County and ANCC staff evaluated two sites but found the sites to be too disruptive to the golf course and discontinued planning efforts (Arlington County DES, 1999).

⁷ A BMP retrofit modifies an existing stormwater BMP or stormwater drainage system to enhance water quality and/or adds water quality components in already developed areas to slow runoff, remove sediment and nutrients, and provide a basis for restoring eroded stream channels (Bell and Champagne, 1998).

On-site detention systems are constructed as part of development and are owned and maintained privately. DPW's Construction Management Section enforces maintenance of these facilities through periodic inspections. A letter is sent and a follow-up inspection is carried out if a problem is found. In FY 1999, no problems were found that required enforcement (Arlington County DES, 1999).

In FY 1999, DPW staff began an updated inventory of privately owned detention systems. Boundaries of development sites built since the County enacted the Storm Water Detention Ordinance were digitized into the GIS system and flagged if detention was part of the project. These were reviewed and compared with the detention systems on the storm sewer map and missing systems were indicated on the file, to be added when map update and maintenance begins. An updated list of detention sites is in preparation for DPW's Construction Management Section (Arlington County DES, 1999).

One significant detention facility in the County is the "Ballston Beaver Pond," a detention storage site for runoff from a 379 acre drainage area (0.6 square miles), including portions of I-66. This facility detains and treats runoff from about one-third of the Lubber Run subwatershed.

2.2.2.2 Street Sweeping

Street sweeping is an important non-structural stormwater BMP because this practice removes pollutant-laden sediments from paved surfaces before this sediment is washed into streets during storms. In Arlington County, street sweeping is conducted by three one-person crews with one operator working primarily at night. These crews have the responsibility for daily sweeping of County streets in commercial corridors to remove sand, salt and particulates. In the spring, the program provides residential street sweeping to remove the accumulations of sand, salt, and debris from the winter season. Four vacuum carts are used for removing litter and debris from the County streets and sidewalks (Arlington County DES, 1999).

DES currently operates three regenerative air sweepers. They are superior to older brush and vacuum technologies and use a closed loop vacuum/blower air system that re-circulates the air internally. This is sound environmental technology that picks up most, but not all, fine particles and that reduces, but does not eliminate, exhausting fine particles, some laden with pollutants, into the air.

Recent work, most notably by Roger Sutherland of Pacific Water Resources and Roger Bannerman of the Wisconsin Department of Natural Resources, has shown that new high-efficiency dry vacuum street sweepers are much more effective than conventional and regenerative street sweepers at removing sediments, especially fine particles, from paved areas (e.g., Sutherland and Jelen, 1996, Bannerman, 1999). However, the new dry vacuum sweepers lack a consistent sustained track record on streets with crowns, uneven surfaces, and other imperfections. They also require twice the capital investment, compared to regenerative air sweepers at this time, and would benefit from more experience in a street environment. However, long-term maintenance costs for dry vacuum sweepers may be lower than for conventional and regenerative air sweepers.

In FY 1998, NVRC and Arlington County submitted a pre-proposal to the Section 319 Nonpoint Source Program of the Virginia Department of Conservation and Recreation to purchase and demonstrate the water quality improvements provided by high efficiency dry vacuum street sweeping. DCR did not invite NVRC and the County to submit a formal proposal.

County staff continue to monitor the evolution of high-efficiency street sweeping technology and hope to be able to add this capability—effectively a "mobile BMP"—to the County's street sweeping equipment as soon as it has a proven track record.

2.2.3 Stormwater infrastructure

DPW's Engineering Division designs storm sewers and sanitary sewers and administers the CIP for storm drainage (DPW's Water, Sewer, and Streets Division will take over this latter function in September 2000). The sanitary sewer system is included in this discussion since leaks from the system can cause water pollution problems.

DPW's Water, Sewer, and Streets (WSS) Division is responsible for cleaning catch basins and manholes, removing storm sewer blockages within 12-24 hours of notice, and repairing broken storm sewer lines throughout the County's approximately 400-mile storm sewer network. Two crews of six people repair all sanitary and storm sewers. Four crews are responsible for flushing both systems (Arlington County DES, 1999). The division has also begun regular cleaning of storm sewer pipes and maintenance of storm sewer outfalls (failed outfalls are repaired only if they threaten public health or safety).

DPW's WSS Division also:

- Updates the storm, sanitary, and water system master plans and administer the CIP projects for these systems;
- Oversees the Infiltration and Inflow (I&I) program to identify entry of stormwater into the sanitary system which can cause bypasses at the Water Pollution Control Plant;
- Notifies Virginia DEQ of sanitary sewer overflows or breaks that leak into streams;
- Covers exposed sanitary lines (usually with rip rap);
- Stabilizes channel erosion if there is a threat to public health or safety; and
- Responds to citizen inquiries about storm and sanitary sewers.

Arlington County's I&I program consists of 20 sanitary sewer flow meters and four rain gauges used to identify areas of high infiltration and inflow of groundwater into the County's sanitary sewer system. Analysis of flow data and rainfall data has indicated that the main source of I&I is wet weather infiltration. Closed circuit TV inspections are used to identify sanitary sewers in need of rehabilitation to prevent infiltration into the system (Arlington County DES, 1999).

2.2.4 Stream and buffer management, restoration, and monitoring

2.2.4.1 Management and restoration

Because most of the County's streams are located within County parkland and many County parks are adjacent to streams, PRCR has a primary role in stream and buffer management. PRCR manages County parkland and designs recreational facilities to minimize stream impacts, protects forested buffers, and practices minimal use of pesticides, herbicides, and fertilizers near streams.

PRCR's Parks and Natural Resources division removes stream obstructions in response to complaints (i.e., no active monitoring occurs). The division also has an informal list of riparian buffer areas where planting to expand buffers could occur, although the division has only limited funds and labor available for implementing planting projects. The division has not implemented a systematic program to control invasive species in buffer areas. Such activities are complaint-driven, however, the division is exploring the possibility of recruiting a volunteer force for removal of invasive vegetation. PRCR also lacks sufficient funds to address streambank erosion in a systematic manner.

DPW also plays a major role in stream management. As discussed in Section 2.2.3, 'Stormwater infrastructure', DPW's Engineering Division administers the CIP for storm drainage—a program which includes streambank stabilization and improvement projects. However, the division does not prioritize such projects on a subwatershed or watershed scale. DPW's WSS division is responsible for streams outside County parkland, but the division's limited budget does not currently fund restoration projects.

The WSS division shares with the City of Alexandria maintenance of the Four Mile Run flood control channel under the Four Mile Run flood control program. The County is responsible for maintaining the hydraulic function of the channel by removing vegetation on the north side of the channel from Interstate-395 to the Potomac River and the entire channel from Shirlington Road to Walter Reed Drive.

2.2.4.2 Monitoring

Until the County-wide stream inventory conducted in the summer of 1999 (see 'Baseline Subwatershed Conditions' section), Arlington County had very little data on the condition of County streams. The inventory, although it provides the most comprehensive information about County streams collected to date, is a screening level tool primarily intended for the watershed planning process. The technique does not supply detailed information about any given stream in the County—especially in-stream water chemistry and biology. However, the County established 15 'long-term' stations during the stream inventory. An outline for the next level of monitoring at these stations is provided in Section 2.6, 'Watershed management recommendations.'

In addition to the data collected through the stream inventory, NVRC and the U.S. Geological Survey (USGS) monitor flow in Four Mile Run at the Shirlington Road bridge as part of the flood control agreement with the U.S. Army Corps of Engineers. Further flow monitoring is planned at other locations within the Four Mile Run watershed. Also, Virginia DEQ operates a long-term monitoring station at the George Washington Bridge (Station 1AFOU000.19) near the mouth of Four Mile Run. Samples are collected and analyzed for a variety of water quality constituents approximately once a month. NVRC performed chemical monitoring in Four Mile Run in 1992 and 1993, and individual citizens and citizen groups have sporadically monitored various County streams. However, in-stream water quality and flow monitoring has been limited County-wide.

2.2.4.2.1 Four Mile Run water quality

Since the samples collected at the Virginia DEQ station are grab samples, they do not provide a continuous record of water quality conditions in Four Mile Run. The data do provide a useful time-series, showing monthly snapshots of water quality conditions. And, these data can be used to evaluate the long-term impact of nitrogen and phosphorous loading reductions at the Arlington WPCP on water quality conditions in Four Mile Run, the Potomac River, and ultimately the Chesapeake Bay.

It should be remembered that this record characterizes the combined impact of both point sources, as well as urban nonpoint sources of various pollutants. Samples were also collected without regard to flow conditions in Four Mile Run, so there may be some atypical values due to samples being taken during high flow conditions, when pollutants are washed into the stream from upstream areas in the Four Mile Run watershed during storms.

Figure 8 shows the historical record for three important water quality constituents. Fecal coliform bacteria are important because they may indicate the presence of other waterborne pathogenic bacteria, viruses, or parasites. They generally are associated with fecal material from any warm-blooded animals, or possible contamination caused by untreated sewage discharges from sewer main breaks or illegal connections to the storm sewer system. Samples at this location are also collected without regard to tidal conditions, so these samples may be influenced by water quality conditions in the Potomac River.

As can be seen in the figure, fecal coliform levels in Four Mile Run are highly variable. The figure shows the Virginia water quality standard of 1000 bacterial colonies per 100 milliliters. Above this level, water contact activities like swimming are discouraged because of the possibility of becoming ill, particularly due to various waterborne gastrointestinal diseases. As can be seen, recent monthly grab samples at George Washington Bridge have regularly exceeded this water quality standard, which is why Four Mile

Run is listed on Virginia's 303(d) listing of impaired waterbodies. Although the long-term median fecal coliform bacteria level, based on 155 samples, is only 200 colonies per 100 milliliter, individual samples as high as 24,000 colonies per 100 milliliter have been recorded.

The WPCP's effluent is normally chlorinated before discharge, even during occasional wet-weather bypass events. For this reason, it is unlikely that the plant is a significant source of fecal coliform bacteria. It is much more likely that most of the fecal coliform bacteria in Four Mile Run is derived from a variety of sources, including urban wildlife (raccoons, geese, rats, squirrels, etc.), improperly disposed pet waste from dogs and cats, and sanitary sewer main leaks or illegal connections to the storm sewer system. Although the County has identified a few sewer leaks during the dry weather inspections program required by the County's stormwater permit, this does not appear to be a common problem.

In terms of nutrients, the long-term record for total nitrate nitrogen at the mouth of Four Mile Run is also highly variable. Nitrate is the form of nitrogen that is most readily available to algae and other aquatic plants. It can contribute to algae blooms and is a major concern in the restoration of the Chesapeake Bay. The median value for nitrates based on 188 samples between 1980 and 1997 is approximately 2.19 milligrams per liter. However, readings over 14 milligrams per liter have been recorded, probably associated with rainfall events. There is currently no State water quality standard for nitrates.

The time series for phosphorus shows a dramatic decline in the levels of phosphorus between 1980 and 1997. This is due in part to the County's significant financial investment in improved treatment efficiency at the WPCP upstream, as well as the effect of the phosphate detergent ban that went into effect in the early 1980's. The median total phosphorus concentration over this period, based on 189 samples, is 0.10 milligrams per liter. There is currently no State water quality standard for phosphorus in streams (unless a water body is declared a nutrient impaired stream). The County's WPCP is required to meet a phosphorus limit of 0.18 milligrams per liter in the treated effluent it discharges to Four Mile Run.

2.2.4.2.2 Stormwater runoff

As required by the County's MS4 permit, DES collects stormwater samples from four storm sewer outfalls in the County. Although these activities do not provide data about in-stream water quality, each of the four outfalls drains a different land use, and the data collected at these outfalls provide information about pollutant concentrations and loadings from four different land use types in the County—commercial, light industrial, low density residential, and medium density residential. The outfall draining commercial land in Shirlington discharges to Four Mile Run adjacent to Arlington Mill Drive, across from South Randolph Street. Another outfall 300 yards upstream from this outfall discharges runoff from the light industrial land uses at the Arlington County Trades Center. A third outfall discharges runoff from the medium density Colonial Village subdivision to Colonial Village Branch near the intersection of N. Rhodes St. and Lee Highway. And, the fourth outfall, located near the intersection of Williamsburg Blvd. and North Potomac Street, discharges runoff to Little Pimmit Run from low-density residential land in North Arlington.

At each of these four outfalls, the County must collect samples during four storms each year—two storms between April and September and two storms between October and March. Stormwater regulators chose these two periods to represent seasonal variations in stormwater pollutant concentrations and loadings. The MS4 regulations require the County to collect flow-weighted composite samples⁸ for parameters such

⁸ During a sampling event, a flow-weighted composite sample is collected in a single container (with the exception of grab samples), and the volume of sample collected in the container during each sample collection interval (e.g., every 15 minutes) is proportional to the flow during the interval.

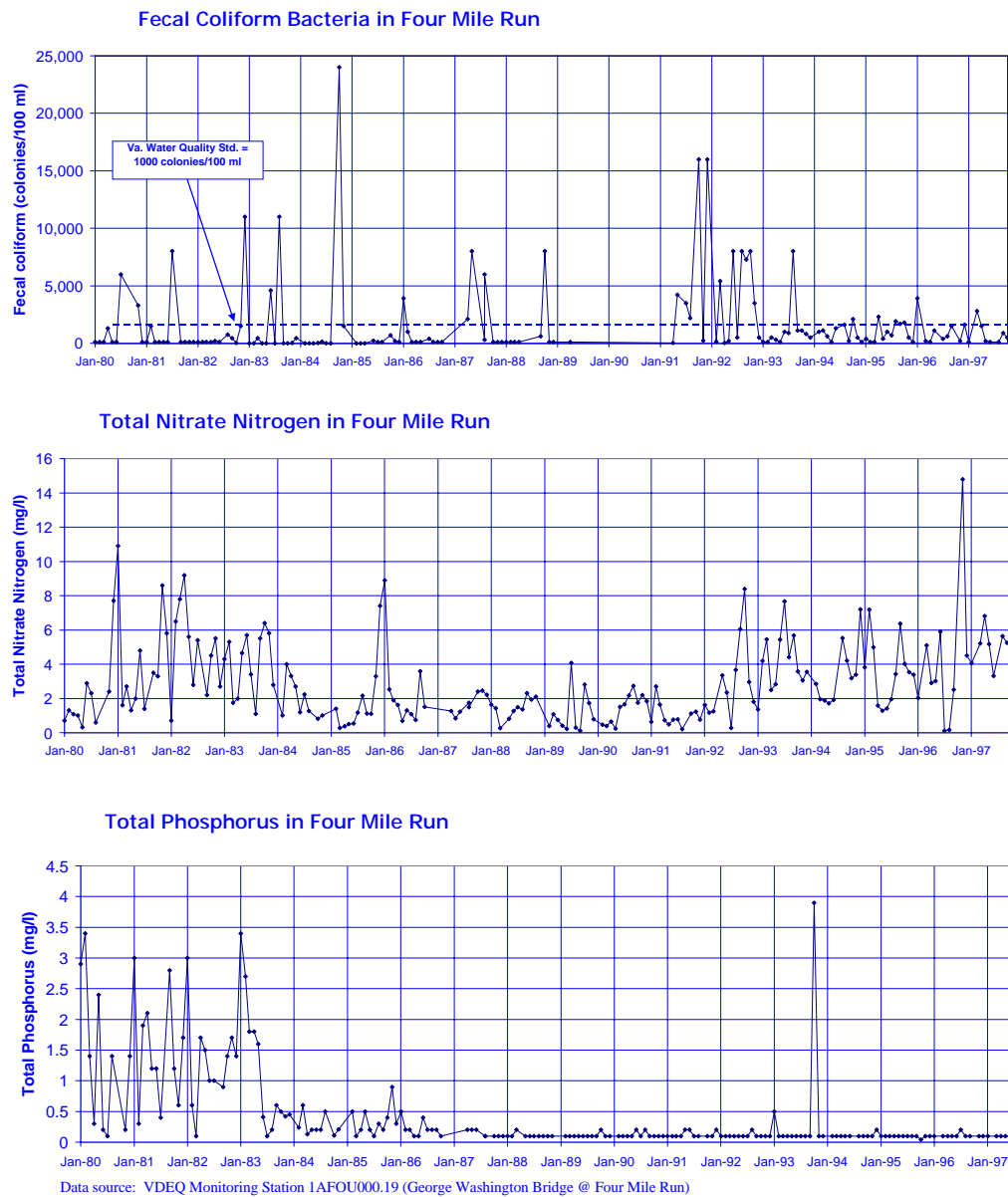


Figure 8. Four Mile Run Water Quality, 1980-1997.

as nutrients and total suspended solids. Grab samples must be collected for parameters such as fecal coliform bacteria and metals. The different sampling approaches for different parameters stem from concerns over total downstream loadings for pollutants such as nutrients versus concerns about the toxic effects of elevated concentrations of pollutants like bacteria and metals. Laboratory analysis of the flow-weighted composite samples collected during each sampling event provides an Event Mean Concentration (EMC) for each parameter analyzed. At each of the four outfalls sampled, the County must calculate seasonal EMCs for the October-March and April-September periods as the average of EMCs at each outfall for all storms sampled during the two periods. For grab samples, the County simply calculates an average concentration for each outfall during each period. For concentrations below method detection limits, a value of half the detection limit is the assumed concentration used in the calculation of EMCs (rather than '0')—a method used by other MS4 permittees such as Los Angeles County (Los Angeles County Department of Public Works, 1999). This is a conservative approach, since compounds below method detection limits may not be present in the sample at all.

For each of the four outfalls covered by the County's MS4 permit, Figure 9, Figure 10, and Figure 11 provide average EMCs for composite sample constituents and average concentrations for grab sample constituents *for all storms sampled at each outfall for which laboratory data are currently available*. Since the issuance of its MS4 permit in FY 1998, the County has monitored 21 storm events as of this writing. Of these events, laboratory data are available at this writing for 18 events: seven events at the industrial outfall, five events at the commercial outfall, three events at the medium density residential outfall, and three events at the low density residential outfall. The results presented should therefore be viewed as preliminary because of the relatively small number of storms sampled at each outfall.

Data for the October-March and April-September periods have been aggregated to simplify the presentation. For comparison, the figures also provide the median, 10th percentile, and 90th percentile values for EMCs of constituents collected during the Nationwide Urban Runoff Program (NURP) during the early 1980s (EPA, 1992)⁹. Also, the figures show State of Virginia water quality standards for acute and chronic aquatic life toxicity and for human health. Acute toxicity measures are more appropriate for stormwater samples because stormwater discharges are episodic in frequency and relatively short in duration. In addition, concentrations of constituents in stormwater discharges from a given outfall are typically diluted by the receiving water body.

Concentrations of the physical parameters analyzed to date are below or within concentration ranges from the NURP study—except for the total dissolved solids (TDS) concentration at the industrial outfall, which is two orders of magnitude higher than the NURP median and one order of magnitude higher than the NURP 90th percentile. Concentrations of total suspended solids (TSS) and hardness are also highest at the industrial outfall.

For organic constituents, concentrations of the oil and grease parameter are within the typical range, except for the industrial outfall, where both oil and grease and total petroleum hydrocarbons (TPH) concentrations were twice as high as at the other outfalls. Given the vehicle and equipment maintenance activities at the Trades Center, this result is not unexpected and points to the need for BMPs such as in-

⁹ To provide a more relevant analysis, Figure 9, Figure 10, Figure 11 compare data collected under the County's MS4 permit with NURP data for the Washington DC area only, where available, rather than nationwide. Washington DC NURP data are available for fecal coliform, fecal streptococcus, total dissolved solids, nitrate+nitrite, total Kjeldahl nitrogen, ammonia, total phosphorus, ortho-phosphorus, and alkalinity (Noel et al., 1987). For oil and grease and total petroleum hydrocarbons, the values shown represent the typical range of hydrocarbons overall found in urban runoff, rather than the NURP median, 10th percentile, and 90th percentile, as reported in Schueler (1987). Sampling and analytical methods during the NURP study may be different from the methods specified in the County's MS4 permit.

line filters to treat runoff from this site. The precise impacts of hydrocarbons on the aquatic environment are not well understood. Only a small number of toxicity tests have been performed to examine the effect of hydrocarbon loads in urban runoff on aquatic communities under the typical exposure conditions found in urban streams (EPA, 1992).

For most of the stormwater samples collected at the four outfalls, concentrations of chloroform were below detection limits. For samples where chloroform was detected, chloroform is a common laboratory contaminant, and the stormwater samples may have been contaminated by laboratory sources of chloroform during sample analysis. In addition, the State of Virginia water quality standard to protect human health is 4,700 micrograms per liter (ug/L) or 4.7 parts per million, more than 800 times the highest average concentration of chloroform among the four outfalls, which were observed at the commercial outfall.

Cyanide concentrations for most of the stormwater samples collected at the four outfalls were also below detection limits. For samples where cyanide was detected, naturally occurring sulfides sometimes interfere with the analytical method for cyanide, resulting in false identification of cyanide in a sample. Further, the Virginia water quality standard to protect human health is 215,000 ug/L, more than 34,000 times the highest average concentration of chloroform at the four outfalls. The Virginia water quality standard for acute toxicity for aquatic life is more than three times the highest average concentration of cyanide at the four outfalls, which was found at the medium density residential outfall (due to one storm's relatively high cyanide concentration).

Nutrient concentrations are within concentration ranges from the NURP study with the exception of dissolved phosphorus at the commercial outfall due to one storm's relatively high concentration. Otherwise, the nutrient data show no discernible pattern among land uses.

For metals, concentrations are below those found during the NURP study. However, because dissolved metals present the most toxicity problems, the MS4 permit requires that all metals samples be filtered before analysis. The NURP study most likely did not analyze filtered metals samples, so analytical concentrations from that study would tend to be higher.

Average metals concentrations at all four outfalls are below Virginia water quality standards¹⁰—except for zinc and copper at the medium density residential site, where average concentrations slightly exceed aquatic life toxicity standards. Both of these metals have been associated with automobile sources, as well as the use of copper gutters.

Bacteria concentrations at all four outfalls are two orders of magnitude higher than NURP concentrations and about 1.5 orders of magnitude higher than the state water quality standard for human health. Among the four outfalls, bacteria concentrations are within the same order of magnitude. Bacterial levels in undiluted runoff from stormwater outfalls usually exceed water quality standards. However, the health implications of high fecal coliform concentrations are unclear, and fecal coliform may not be consistently reliable in identifying human health risks from urban runoff pollution (EPA, 1992).

¹⁰ Water quality standards for cadmium, copper, lead, silver, and zinc are a function of water hardness. For this analysis, the average hardness value for all sites of 70 mg/L was used to calculate acute and chronic water quality standards with which to compare the average metals concentrations at the four outfalls.

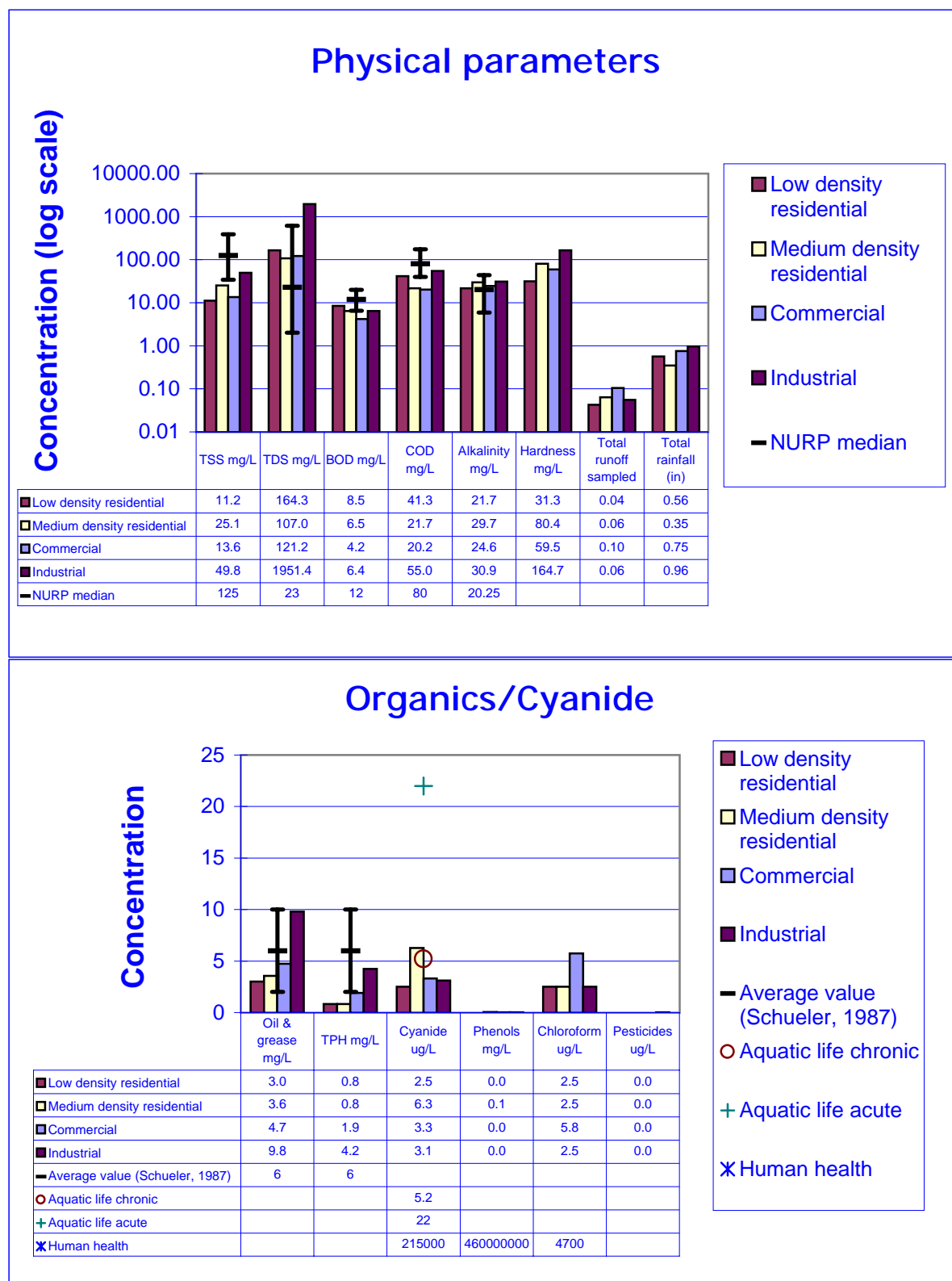


Figure 9. Average concentrations of physical and organic/cyanide parameters at four MS4 outfalls.

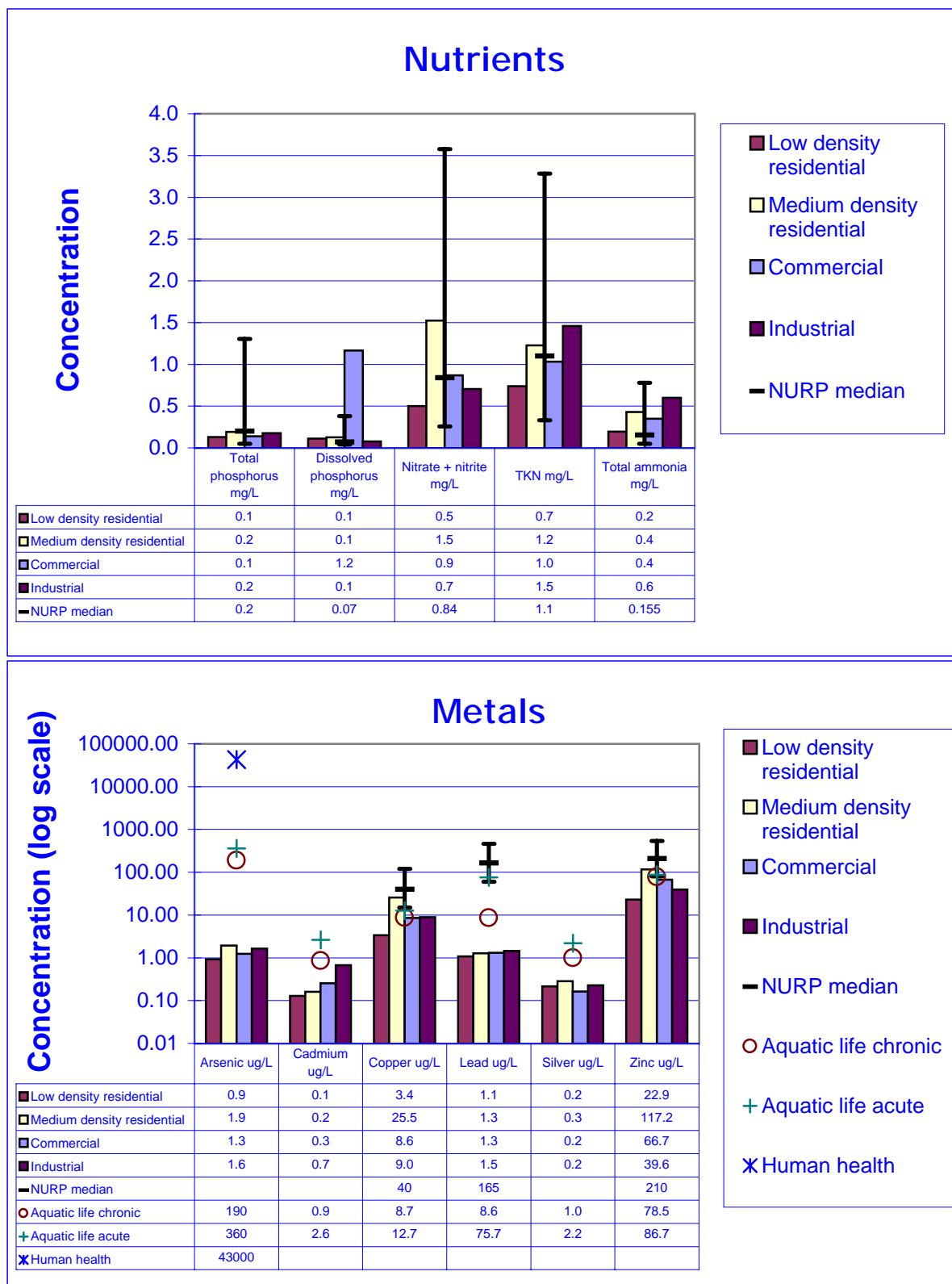


Figure 10. Average concentrations of nutrients and metals at four MS4 outfalls.

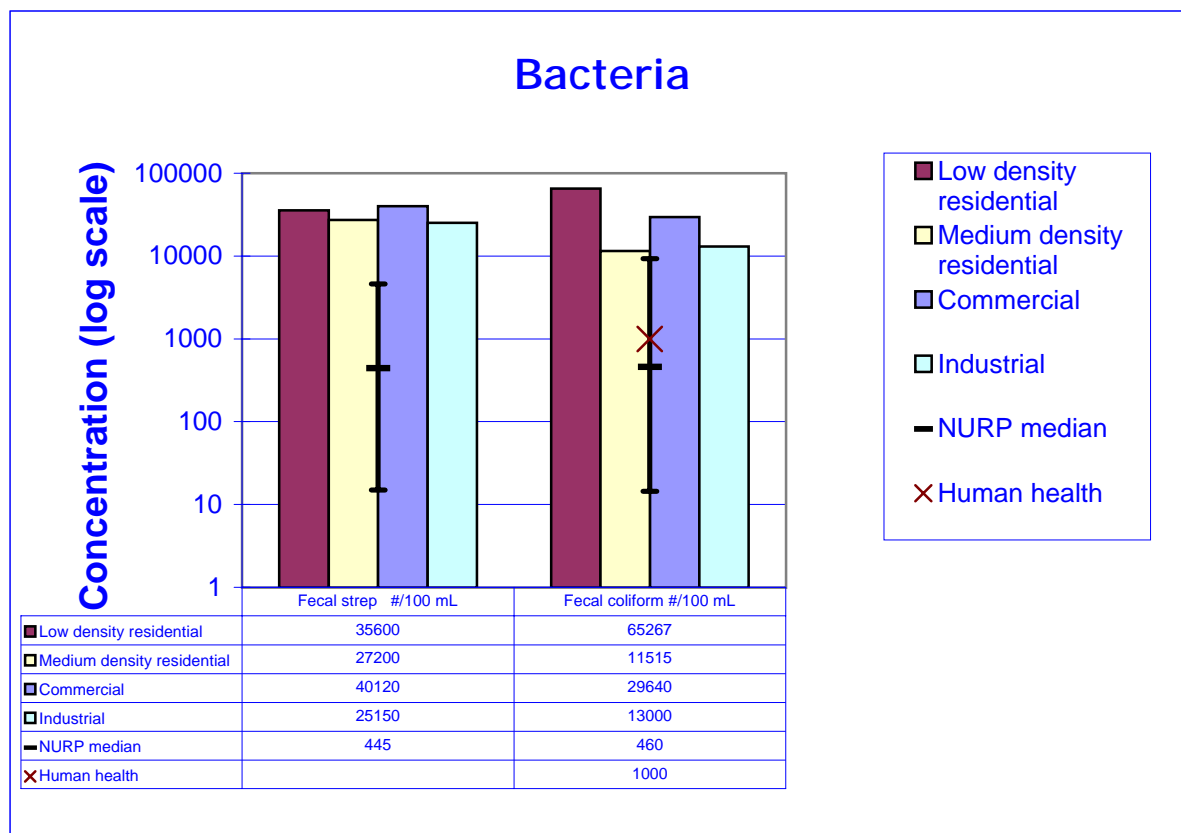


Figure 11. Average concentrations of bacteria at four MS4 outfalls.

2.2.5 Pollution prevention and watershed education

Pollution prevention, or source reduction, methods are an important complement to structural BMPs such as stormwater ponds, especially in areas such as Arlington County where development occurred before structural BMPs were required (NVRC, 1997). Pollution prevention activities include public education, improved lawn and turf care practices, street sweeping, and other activities that can result in water quality improvements by targeting practices and behaviors that cause the pollution (NVRC, 1997). Arlington County and its partners conduct a number of educational programs that emphasize pollution prevention and watershed protection. These programs are summarized below. Street sweeping is included in the 'Stormwater BMPs, BMP maintenance, and retrofits' section above rather than this section because of its importance to an effective BMP implementation program. This section emphasizes education-based pollution prevention activities.

2.2.5.1 Arlingtonians for a Clean Environment (ACE)

ACE is a non-profit educational and service organization serving the residents of Arlington County and funded primarily through DES. ACE has presented information to students and adults about local issues including non-point source pollution and the Chesapeake Bay. Several schools participate each year in schoolyard outdoor educational programs which include stream walks. ACE also leads cleanups of local streams and publishes a quarterly newsletter, "The Arlington Environment," highlighting environmental issues that impact Arlington County residents. Approximately 1,500 copies are mailed and 1,000 are distributed by ACE every quarter. ACE also has an email distribution list for volunteer and educational opportunities (Arlington County DES, 1999).

In February 1999, ACE unveiled three new interpretive signs in Barcroft Park that will greet recreational users with messages about water quality. The signs were designed to educate people about how their activities affect the quality in the Four Mile Run watershed and ultimately the Chesapeake Bay. ACE developed the signs with a grant from the Alliance for the Chesapeake Bay and collaborated with a number of County agencies and other local organizations on this project, including the Arlington County Cultural Affairs Division, Neighborhood Conservation Program, PRCR, DES, the Barcroft School and Civic League, and the Glencarlyn Citizens Association.

The County will use the signs in a new park being planned for the area where Four Mile Run crosses Columbia Pike. The signs have already been reproduced for use along other sections of the Four Mile Run stream. Information on reprinting signs is available from the ACE office.

2.2.5.2 Department of Parks, Recreation and Community Resources Educational Programs

The Conservation & Interpretation (C&I) Section of PRCR provides environmental education programs and technical information and referral on environmental topics to the residents of Arlington through the staff of the County nature centers. The Park Ranger program is also part of the C&I Section. As part of their mission, the Park Rangers serve as on-site monitors in County parks, ensuring park user compliance with County ordinances and emphasizing environmentally responsible behaviors during their citizen interactions. The nature centers offer water-related educational and volunteer project opportunities to both the general public and school groups on an on-going basis.

In FY 1999, the nature centers sponsored nine stream cleanups, presented 49 programs that had watershed education as their theme, and trained a number of volunteer stream monitors. Additionally, the C&I Section has developed the Project Watershed Watch (PWW) program. Since its inception, over 24,000 people have participated in hands on watershed education offered through this program. Project Watershed Watch has twice been awarded the Take Pride in America award. Through a variety of organized activities and educational programs, citizen volunteers have donated approximately 7,000 hours of labor to improve Arlington's water resources. Additionally, volunteers have removed more than 39 tons of trash from Arlington streams and associated parklands during sponsored clean-ups. As part of

PWW, in 1997, the C&I Section produced and distributed educational brochures regarding stream safety to every child enrolled in Arlington public schools. In 1998, multi-lingual signs regarding safe stream behavior were developed and posted in all County park kiosks. During FY 1999, the C&I Section worked cooperatively with ACE, NVRC, and others to develop and install interpretive signage with watershed education as its theme, for installation in County parks. Literature regarding PWW activities is mailed to approximately 1,000 households, and an additional 1,000 copies are distributed biannually.

PRCR is also developing both a list of places to implement 'no-mow' areas and a list of areas to install plantings to increase and improve riparian buffers in Arlington parks. A critical component of this work will be coordination with any planned streambank restoration. Internally, PRCR is considering natural resource management education for its field crews. PRCR is also developing an educational brochure for public distribution about invasive plants and planting alternatives.

To promote tree planting, PRCR's Parks and Natural Resources Division oversees a Public Tree Planting Program through which citizens can suggest locations for the County to fund plantings on public land. This is one mechanism to expand riparian buffer areas. In addition, in 1999, the Arlington Forest Civic Association started a program that will pay for (through civic association dues) half of the cost to plant trees in residents' front yards (there often is not enough space to plant trees between the sidewalk and the street). PRCR hopes to encourage similar programs in other civic associations (Feldberg, 2000).

2.2.5.3 County Fair

The Department of Environmental Services had a display booth at the annual Arlington County Fair in August 1998. Information on such topics as Household Hazardous Waste, water conservation, composting, watershed management, recycling and wastewater treatment was provided. Approximately 60,000 people attend the Fair every year. The Department's display booth received an award from the fair organizers for the quality of its outreach efforts (Arlington County DES, 1999).

2.2.5.4 Non-point Source Public Education Materials

County staff developed a non-point source pollution brochure with the Northern Virginia Planning District Commission and has distributed it at various events, including the County Fair.

2.2.5.5 Bacteria Source Identification

Like most urban streams, Four Mile Run is impaired by fecal coliform bacteria contamination. In July, 1999, Virginia DEQ awarded NVRC a grant, with full County support, to use DNA testing to determine the source(s) of fecal contamination in the watershed. The results, released in October 2000, suggest that most sources of bacteria in Four Mile Run are not readily controllable because they come from urban wildlife. Waterfowl, raccoon, and deer accounted for over 60 percent of the bacterial DNA samples collected in the watershed. In contrast, human DNA was identified in 17 percent of the samples, while dog DNA was identified in only nine percent of the samples.

2.2.5.6 Pet Waste Education

Because dogs are one possible source of fecal coliform contamination in Four Mile Run, County staff worked with several citizen groups to develop an informational brochure aimed at educating dog owners about non-point source nutrient and bacterial pollution. The brochure urges dog owners to pick up after their dogs and dispose of the waste properly. This brochure has been distributed at County parks, by the Animal Welfare League and will be distributed by the County's Treasurer's office in dog registration renewal notices (Arlington County DES, 1999).

2.2.5.7 Dog Exercise Areas

In March 1998, the County Manager initiated a joint citizen/staff work group to draft standards for off-leash Dog Exercise Areas (DEAs). The group was asked to address size, use, carrying capacity, sponsorship, rules, environmental impacts, containment, ground cover, funding, and complaints. Public

meetings were held monthly from June 1998 to March 1999 and two public forums were conducted. Final standards were issued in May 1999. Properly established and maintained DEAs are expected to improve water quality by concentrating pet activity away from stream edges and by encouraging owners to collect and dispose of waste before it contaminates the watershed (Arlington County DES, 1999). PRCR has already identified several existing DEAs that may be relocated because of their proximity to streams. PRCR is also considering developing educational kiosks for DEAs and other public spaces.

2.2.5.8 Cooperative Extension Homeowner Lawn Care Education

The Arlington office of the Virginia Cooperative Extension (VCE) Service is responsible for public outreach and education about lawn care and maintenance in the County. In 1998, the Arlington VCE office received a Virginia Water Quality Improvement Fund grant to develop an Urban Nutrient Management program in the County to educate suburban homeowners about nutrient management practices that protect water quality and also allow for attractive and sustainable lawns and landscapes.

Through this program, known as the “Water-wise Gardener” program, the Arlington VCE office develops seminars and publications that focus on fertilizer and pesticide use, soil testing, composting, and Integrated Pest Management. The three seminars scheduled for Fall 1999 include “Soil Testing, Aerating, and Overseeding,” “Fertilizing and Weed Control,” and “Composting and Winter Treatment.”

Arlington VCE estimates that the 35 participants in the Fall 1998 Water-wise Gardener program used approximately 80 fewer pounds of nitrogen as a result of the program. Arlington VCE continued this project in FY 1999 with additional funding from the Water Quality Improvement Fund, and DES staff will continue to work closely with the Arlington VCE office (Arlington County DES, 1999).

2.2.5.9 Pesticide and Herbicide Use

PRCR continues to maintain a list of approved pesticide and herbicide products and uses and to train and license staff in application methods and safety measures.

2.2.5.10 Storm Drain Stenciling

Since 1997, ACE has stenciled approximately 40 storm drains in two neighborhoods, Rosslyn and Colonial Village, as well as at Williamsburg Middle School, with the message “Don’t Dump – Chesapeake Bay Drainage” (Arlington County DES, 1999). In addition, in the early 1990s, NVRC and DPW sponsored a storm drain stenciling pilot program in Arlington.

2.2.5.11 Household Hazardous Waste Program

Arlington County operates a permanent, year-round and no-fee Household Hazardous Waste drop-off facility at the Water Pollution Control Plant for residents. Materials collected are stored at the facility until a scheduled pick-up by a licensed hazardous waste disposal contractor. The materials are recycled, incinerated for BTU recovery, neutralized or disposed of in a permitted hazardous waste facility. The facility accepts typical HHW items as well as latex paint (program established October 1997) and household batteries. Batteries can also be dropped off at most Arlington County Fire Stations. Resident participation in the program continues to increase. In FY 1999, 182,000 pounds of household hazardous wastes were collected, up 25% from FY 1998. There were 736 calls to the County and 1,339 drop-offs

Through events such as the bi-annual Household Hazardous Waste Roundup Days, County Fire Department Open House nights, and the County Fair, staff is working to educate residents about HHW disposal and alternatives. The part-time HHW coordinator also makes presentations to school children and community groups upon request (Arlington County DES, 1999).

2.2.5.12 Oil Recycling

Motor oil can be taken to many participating automotive service stations in Arlington County for recycling. If the oil has been mixed with water, solvents, or fuel, residents can bring it to the Household

Hazardous Waste drop off center at the County's Water Pollution Control Plant for proper disposal. In September 1998, a new 150-gallon capacity used oil collection center opened at the HHW facility and 820 gallons were collected. This unit is secured with a padlock to prevent accidental contamination from untested sources. No businesses are allowed to use this site (Arlington County DES, 1999).

2.3 Baseline subwatershed conditions

2.3.1 Streams

To begin the watershed planning process and identify watershed protection and restoration priorities, EPO hired a consultant, Environmental Systems Analysis, Inc. (ESA), to conduct a stream and riparian buffer inventory, using a modified version of the Rapid Stream Assessment Technique (RSAT) to assess the condition of the County's streams and buffers. RSAT is a field screening approach developed in 1992 by John Galli of the Metropolitan Washington Council of Governments (COG) to conduct watershed-wide analyses for Piedmont streams (Galli, 1996). RSAT incorporates chemical, biological, and physical indicators to evaluate stream health relative to a reference stream known to have reaches in good condition. For this study, the reference stream is based on the best conditions observed in the relatively less developed Gulf Branch subwatershed, located in the Palisades area of north Arlington. ESA recommended the use of Gulf Branch as the reference stream, rather than a pristine Piedmont stream, to represent the best achievable conditions in an urban environment.

2.3.1.1 Methods

The original RSAT approach assigns points to six stream and riparian parameters, which are based on approximately 30 quantitative and qualitative measurements, evaluated at a given stream reach. The six parameters include channel stability, channel scouring/deposition, physical instream habitat, water quality, riparian habitat conditions, and biological indicators. In consultation with County staff, ESA modified the RSAT approach to evaluate seven parameters on a 0-56 point scale. ESA replaced the biological indicators parameter, which requires extensive field work, with an aesthetic rating parameter that considers the amount of litter and refuse in the stream or adjacent streambanks, as well as the condition of riparian vegetation, and a remoteness parameter which essentially reflects the accessibility of the site. The County intends to perform additional biological sampling at 15 permanent monitoring stations in the future, based on more rigorous biological monitoring criteria recommended by U.S. EPA.

The descriptive criteria used to assign points to each parameter are described in Table 2. Additional information about these criteria is provided in ESA's final report. These criteria include both quantitative measures and qualitative evaluations based on best professional judgement. Note that for each parameter, point values are divided at equal intervals into four qualitative categories: excellent, good, fair, and poor. These qualitative categories are for general comparative purposes only. The numeric RSAT score is the more important indicator of stream health.

In May 1999, ESA, with assistance from County staff, surveyed 28.5 miles of natural stream channels in the County, evaluating the seven stream and riparian parameters at 400-foot intervals and wherever ESA observed unique or hazardous conditions. ESA evaluated a total of 236 stations in 16 subwatersheds. ESA did not evaluate an additional 85 stations because of limited access to streams through private land or because riffles were not present along the reach.¹¹ In addition, ESA also did not evaluate the Cemetery/Pentagon, National Airport, and Roaches Run subwatersheds because of a lack of perennial

¹¹ The RSAT methodology is designed for use at riffles since they represent optimal habitat for most aquatic organisms. Although some RSAT stations were located in the Coastal Plain rather than the Piedmont, ESA only evaluated stations where riffles were present. Therefore, the use of the RSAT technique in the County's Coastal Plain streams should provide acceptable data.

streams and only evaluated stream reaches within Arlington County for those subwatersheds that extend into adjacent jurisdictions, such as Pimmit Run, Little Pimmit Run, and Upper Long Branch.

To supplement the modified RSAT data, ESA established long-term monitoring stations at 15 sites in 10 subwatersheds in August 1999 (Figure 12). At these 15 stations, ESA collected macroinvertebrate samples, surveyed baseline channel cross sections, and installed bank pins to provide future measurements of erosion, downcutting, and widening. These data, and additional water quality/quantity and habitat data, will be collected at these stations to measure stream and riparian buffer conditions over time (see Section 2.6.4.2, 'Monitoring').

2.3.1.2 Results

Composite RSAT scores by subwatershed—calculated by averaging the scores at each station in a subwatershed for each of the seven RSAT parameters and then summing these averages—are shown in Table 3 and Figure 13. Four of the 16 subwatersheds are considered in 'good' condition and 12 are in 'fair' condition. The four subwatersheds with RSAT scores in the 'good' category comprise 12 percent of the total area of the 16 subwatersheds evaluated, and two of these subwatersheds, Pimmit Run and Upper Long Branch, are not completely contained within Arlington County. The conditions of reaches in the portions of these subwatersheds outside of Arlington County are therefore unknown.

The Gulf Branch subwatershed is actually the highest scoring of the watersheds located fully within the County. The composite RSAT score for this subwatershed, along with the RSAT scores for two of the three other subwatersheds in the 'good' category (Pimmit Run, Upper Long Branch), is close to the breakpoint between the 'good' and 'fair' categories (the other subwatershed in the 'good' category, Potomac Direct (A), has only one RSAT station). The subwatershed with the lowest RSAT score is Spout Run, with an RSAT score two points above the 'poor' category. Like the composite RSAT scores for each subwatershed, the majority of RSAT stations scores (65 percent) fall into the 'fair' category. Seven percent of RSAT station scores are in the 'poor' category, and 28 percent fall into the 'good' category. Figure 14 shows the 16 subwatersheds evaluated and the RSAT scores for each station, and Figure 15 shows the distribution of RSAT scores for the 236 stations.

Table 4 and Figure 16 show the average value for each of the seven RSAT parameters in each subwatershed that comprise the composite subwatershed RSAT score. In general, most of the subwatersheds have 'good' to 'excellent' scores for the channel stability and channel scouring/sediment deposition parameters. The range of scores for these two parameters is relatively narrow and tends toward the middle and upper end of the scale. In contrast, the range of scores for the physical in-stream habitat, riparian habitat, and aesthetic parameters is wider. No watershed received an average water quality or remoteness score higher than the 'fair' range. Not surprisingly, the distribution of scores for each RSAT parameter at all 236 stations follows a pattern similar to the average parameter scores in each subwatershed. The majority of the RSAT parameter scores fall into the 'good' category for the two stream morphology parameters, channel stability and channel scouring/deposition. However, the majority of scores for the habitat parameters (physical in-stream habitat and riparian habitat) and the water quality parameter are in the 'fair' to 'poor' range. Similarly, most of the scores for the aesthetic rating and remoteness parameters fall into the 'fair' to 'poor' range. The full results of the stream inventory, including original field data sheets and a photo inventory, are provided in ESA's final report to the County (ESA, 1999).

Parameter	Excellent	Good	Fair	Poor
Channel stability	<ul style="list-style-type: none"> • >80% stable banks • Outside banks <2' high, very stable • Exposed roots lacking • Channel highly resistant 	<ul style="list-style-type: none"> • 71-80% stable banks • Outside banks 2-3' high, stable • Exposed roots old, large • Channel resistant 	<ul style="list-style-type: none"> • 50-70% stable banks • Outside banks 3-4' high, unstable • Exposed roots young, common • Channel erodible 	<ul style="list-style-type: none"> • <50% stable banks • Outside banks >4' high, highly unstable • Exposed roots young, abundant • Channel highly erodible
Points	9 – 11	6 – 8	3 – 5	0 – 2
Channel scouring/sediment deposition	<ul style="list-style-type: none"> • <25% embedded silts, sands • High number of deep pools • Sand deposits rare, absent • Point bars fully incorporated • Water clear • Riffle bends frequent 	<ul style="list-style-type: none"> • 25-50% embedded silts, sands • Moderate number of deep pools • Sand deposits uncommon • Point bars stable, vegetated • Water slightly turbid • Riffle bends common 	<ul style="list-style-type: none"> • 50-75% embedded silts, sands • Low-moderate number of deep pools • Sand deposits common • Point bars large, unstable • Water generally turbid • Riffle bends not common 	<ul style="list-style-type: none"> • >75% embedded silts, sands • Few, if any, deep pools • Sand deposits predominant • Point bars unstable with fresh sand • Water opaque • Riffle bends generally lacking
Points	7 – 8	5 – 6	3 – 4	0 – 2
Physical in-stream habitat	<ul style="list-style-type: none"> • Wetted perimeter >85% • Riffle run pool, diverse habitat • Pools >24", dense cover structure • Riffle substrate >50% cobble gravel 	<ul style="list-style-type: none"> • Wetted perimeter 61-85% • Riffle run pool, relatively diverse • Pools 18-24", some cover structure • Riffle substrate 30-50% cobble gravel 	<ul style="list-style-type: none"> • Wetted perimeter 40-60% • Riffle run pool, few pools • Pools 12-18", little cover structure • Riffle substrate 10-30% cobble gravel 	<ul style="list-style-type: none"> • Wetted perimeter <40% • Riffle run pool, poor habitat • Pools <12", no cover structure • Riffle substrate <10% cobble gravel
Points	7 – 8	5 – 6	3 – 4	0 – 2
Water quality	<ul style="list-style-type: none"> • Clarity, visibility >3' • No odor • Substrate fouling 0-10% 	<ul style="list-style-type: none"> • Clarity, visibility 1.5-3' • Slight organic odor • Substrate fouling 11-20% 	<ul style="list-style-type: none"> • Clarity, visibility 0.5-1.5' • Moderate organic odor • Substrate fouling 21-50% 	<ul style="list-style-type: none"> • Clarity, visibility <0.5' • Strong organic odor • Substrate fouling >50%
Points	7 – 8	5 – 6	3 – 4	0 – 2
Riparian habitat	<ul style="list-style-type: none"> • Forested buffer >200' • Canopy closure >80% • Bank vegetation 90% • Adjacent wetlands 100-200' 	<ul style="list-style-type: none"> • Forested buffer 100-200' • Canopy closure 60-80% • Bank vegetation 70-90% • Adjacent wetlands 200-500' 	<ul style="list-style-type: none"> • Forested buffer 50-100' • Canopy closure 50-60% • Bank vegetation 50-70% • Adjacent wetlands >500' 	<ul style="list-style-type: none"> • Forested buffer <50' • Canopy closure <50% • Bank vegetation <50% • Adjacent wetlands rare to none
Points	6 – 7	4 – 5	2 – 3	0 – 1
Aesthetic rating	<ul style="list-style-type: none"> • Human refuse little to none • Vegetative matrix natural state 	<ul style="list-style-type: none"> • Human refuse minor • Vegetative matrix minor disturbance 	<ul style="list-style-type: none"> • Human refuse moderate • Vegetative matrix moderate disturbance 	<ul style="list-style-type: none"> • Human refuse extensive • Vegetative matrix vegetation lacking
Points	6 – 7	4 – 5	2 – 3	0 – 1
Remoteness	<ul style="list-style-type: none"> • Access >500' 	<ul style="list-style-type: none"> • Access <500' 	<ul style="list-style-type: none"> • Access roadside or trail 	<ul style="list-style-type: none"> • Access in backyards
Points	6 – 7	4 – 5	2 – 3	0 – 1
Total points	48 – 56	33 – 41	18 – 26	0 – 11
Qualitative RSAT ratings	Excellent 45 – 56	Good 30 – 44	Fair 15 – 29	Poor 0 – 14

Table 2. Criteria and points used to assign RSAT scores under modified RSAT method.

Subwatershed	No. of RSAT stations	Composite RSAT score (0-56 scale)	Qualitative Rating
Colonial Village/Rocky Run	5	21	Fair
Doctor's Branch	9	22	Fair
Donaldson Run	39	26	Fair
Four Mile Run, Lower Mainstem	10	23	Fair
Four Mile Run, Middle Mainstem	22	26	Fair
Four Mile Run, Upper Mainstem	51	26	Fair
Gulf Branch	14	33	Good
Little Pimmit Run	9	27	Fair
Lower Long Branch	28	23	Fair
Lubber Run	12	27	Fair
Pimmit Run	7	34	Good
Potomac Direct (A)	1	38	Good
Potomac Direct (B)	5	22	Fair
Spout Run	4	16	Fair
Upper Long Branch	10	32	Good
Windy Run	10	27	Fair

Table 3. Number of RSAT stations and composite RSAT scores for 16 subwatersheds.

Subwatershed	Channel stability (0-11)	Channel scouring/sediment dep. (0-8)	Physical in-stream habitat (0-8)	Water quality (0-8)	Riparian habitat (0-7)	Aesthetic rating (0-7)	Remoteness (0-7)
Colonial Village/Rocky Run	4.8	3.6	3.0	2.6	3.0	2.4	1.6
Doctor's Branch	6.2	5.1	3.2	2.1	2.0	1.9	1.1
Donaldson Run	5.5	4.7	4.0	3.2	3.7	3.4	1.9
Four Mile Run, Lower Mainstem	7.3	5.4	3.2	3.3	0.9	1.4	1.2
Four Mile Run, Middle Mainstem	7.0	5.8	4.0	3.5	2.5	2.3	0.9
Four Mile Run, Upper Mainstem	6.2	4.4	4.1	3.1	2.7	2.7	2.0
Gulf Branch	7.3	5.3	4.6	3.8	4.4	4.6	2.7
Little Pimmit Run	6.3	4.8	2.8	2.7	3.7	4.0	1.8
Lower Long Branch	6.8	4.4	3.0	3.6	1.4	2.1	1.4
Lubber Run	7.3	4.7	3.8	2.8	3.1	3.3	1.9
Pimmit Run	8.6	6.9	5.6	4.1	3.6	4.1	1.4
Potomac Direct (A)	8.0	5.0	6.0	4.0	6.0	6.0	3.0
Potomac Direct (B)	4.2	3.8	3.6	3.4	3.4	2.2	1.4
Spout Run	7.0	5.3	1.3	0.5	1.3	1.0	0.3
Upper Long Branch	7.1	5.9	5.7	3.9	4.1	3.5	2.0
Windy Run	4.9	5.0	3.4	4.0	3.9	3.7	1.8
Range	4.2 – 8.6	3.6 – 6.9	1.3 – 6.0	0.5 – 4.1	0.9 – 6.0	1.0 – 6.0	0.3 – 3.0

Table 4. Average values for seven RSAT parameters for 16 subwatersheds.

Figure 12. Locations of 15 long-term monitoring stations.

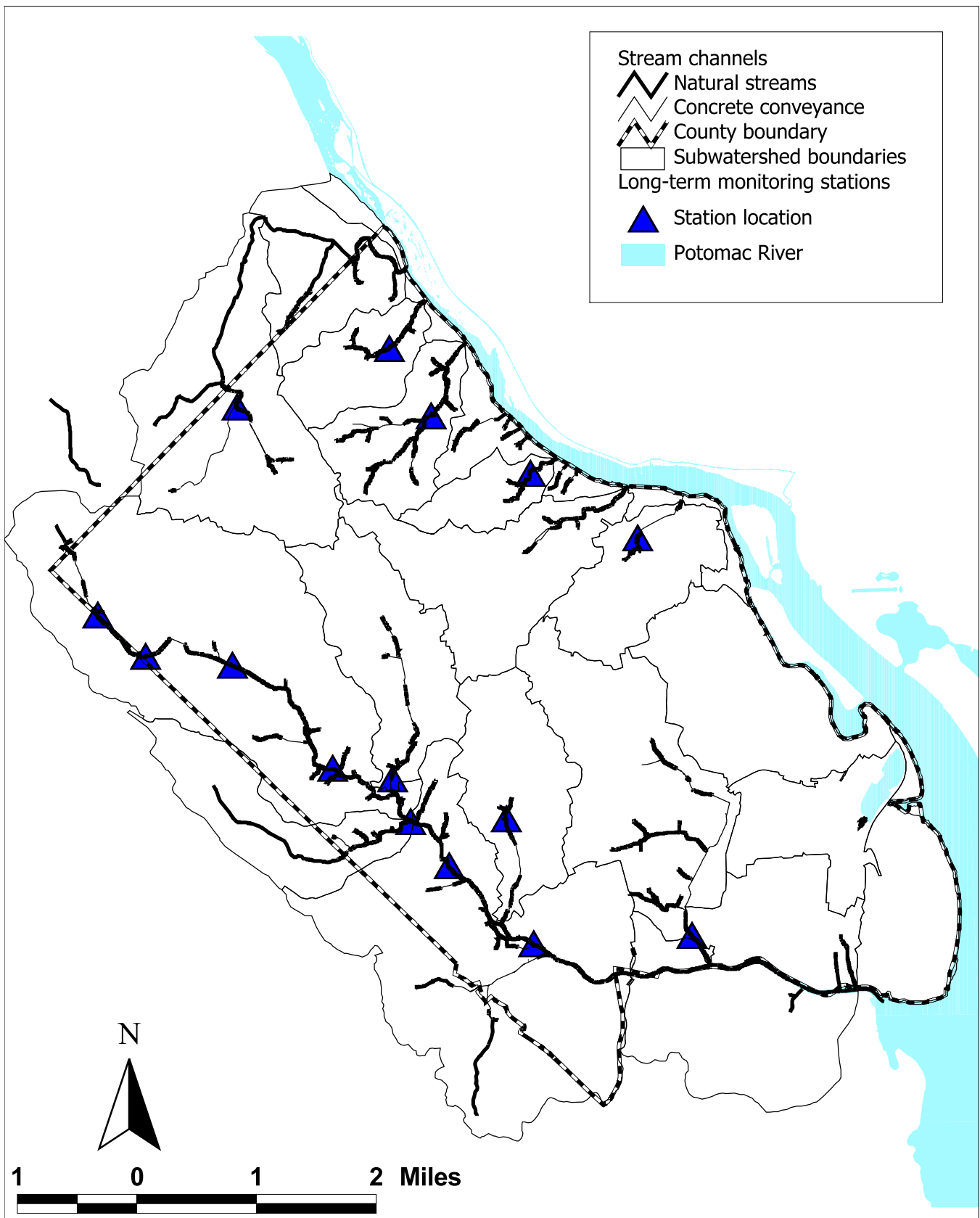


Figure 13. Composite RSAT scores for 16 subwatersheds.

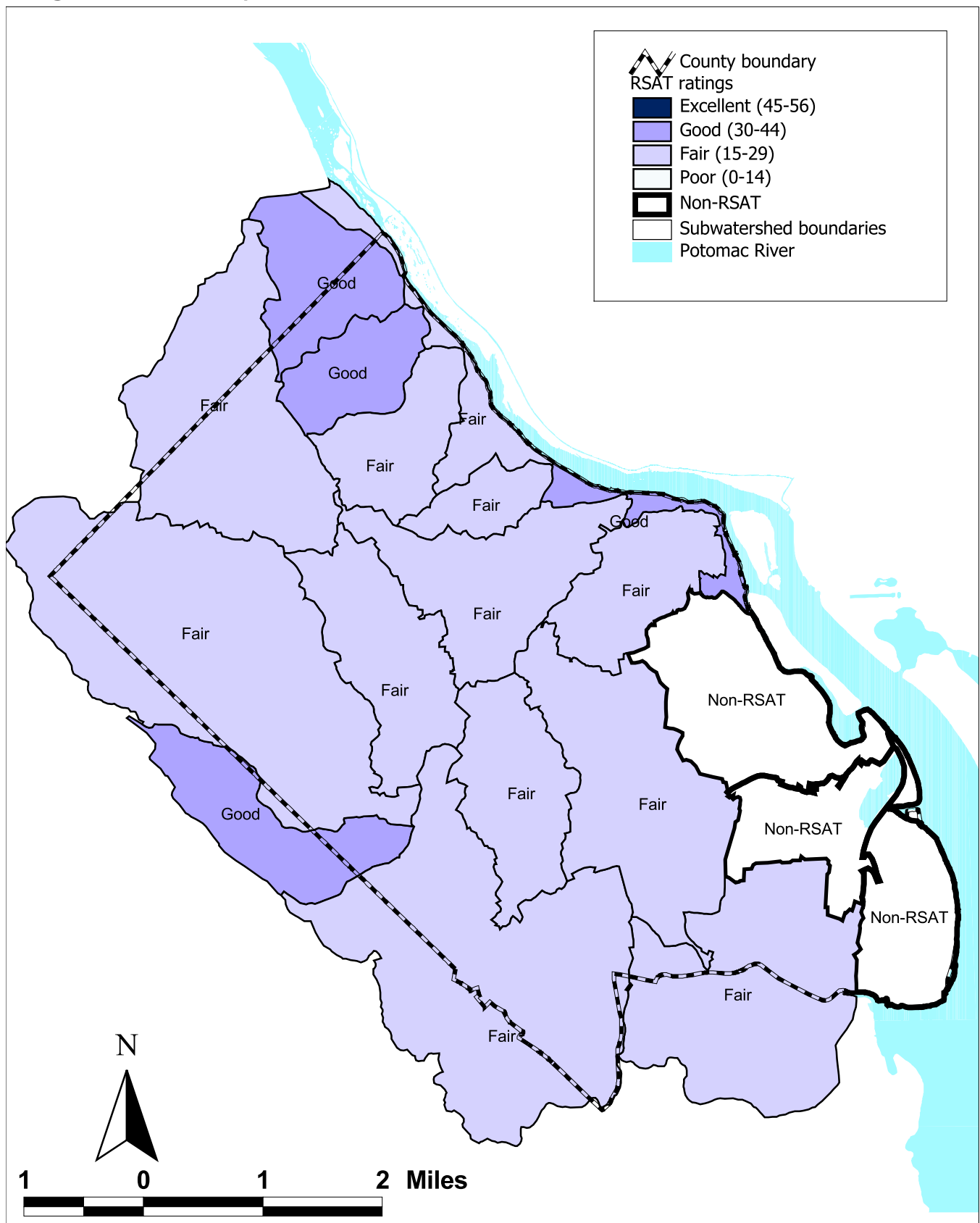
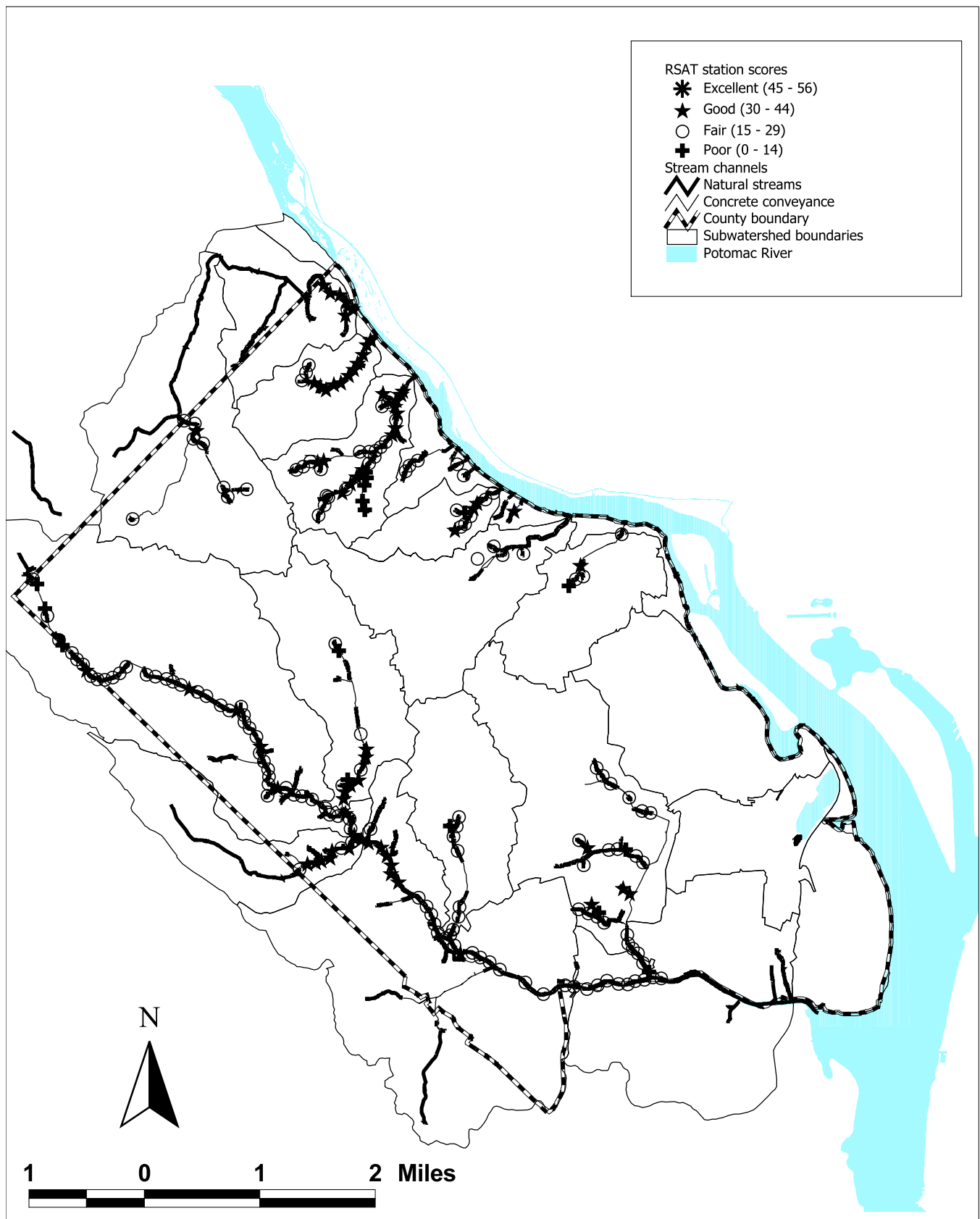


Figure 14. RSAT station scores in 16 subwatersheds.



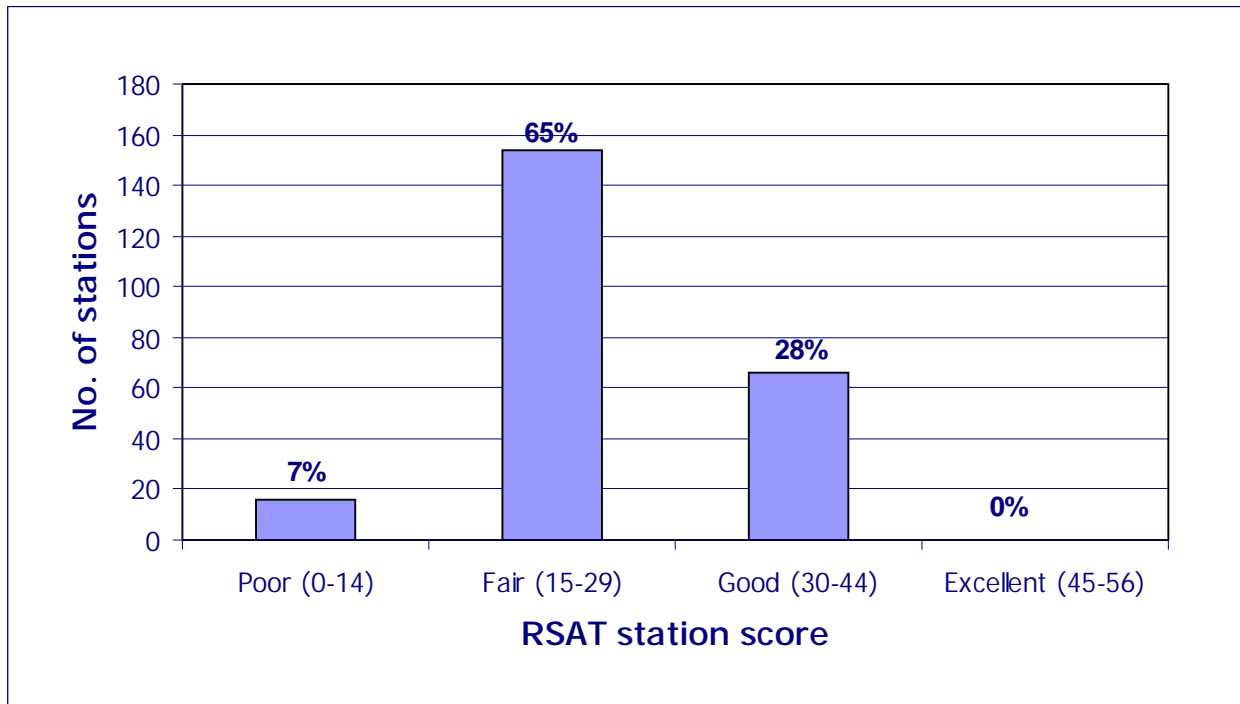


Figure 15. Distribution of RSAT station scores for 236 stations.

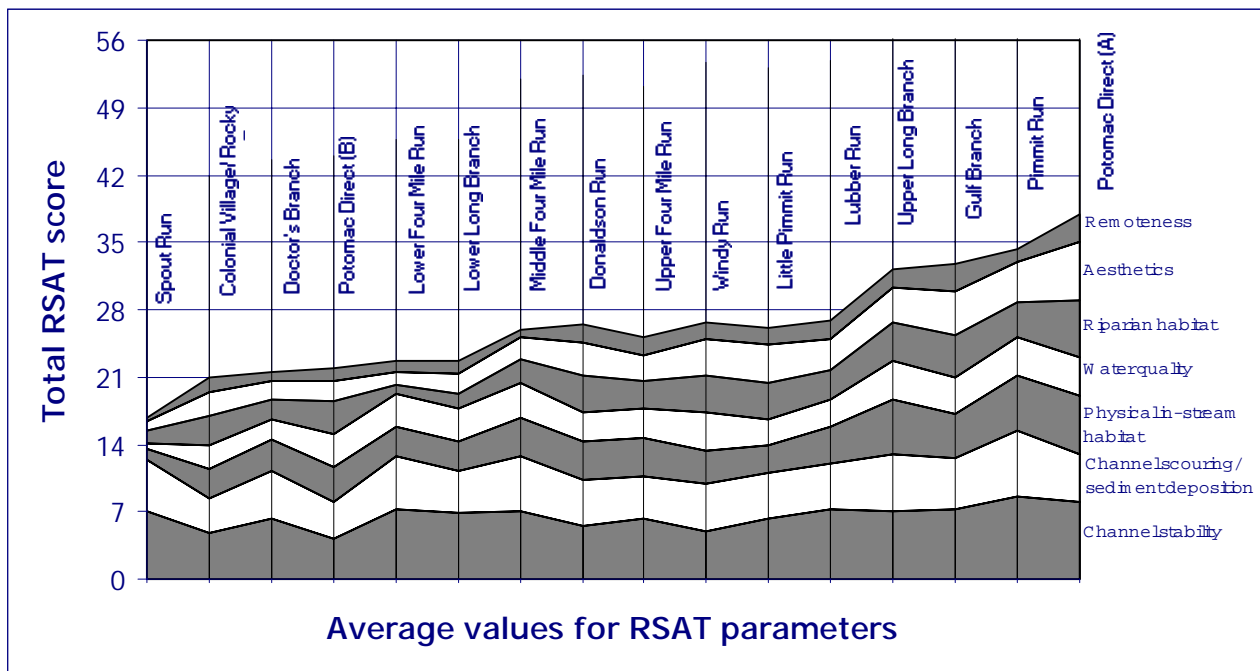


Figure 16. Average values for seven RSAT parameters for 16 subwatersheds.

2.3.1.3 Discussion

The RSAT data suggest that most of the subwatersheds in Arlington County are in 'fair' condition, with somewhat better stream conditions in the lower-density Palisades portion of the County and stream-valley parks such as Upper Long Branch and Lubber Run. In these subwatersheds, and at specific stream reaches in relatively good condition in other subwatersheds, management activities should focus on stream protection and restoration, where feasible and appropriate. Specific management recommendations are discussed in Section 2.6.4.1, 'Management and restoration.'

The fact that the majority of scores for the channel stability and channel scouring/sediment deposition parameters were in the 'good' to 'excellent' range reflects the 'built-out' condition of the County. Recent research indicates that it may take 50 to 75 years for stream channels to adjust to development, with shorter adjustment periods for streams with harder bed material (Caraco, 2000). Most of Arlington's stream channels, especially the harder streambeds in the Piedmont portion of the County, appear to have adjusted to increased flows from mostly older development projects and have reached or are approaching new 'equilibrium' states. In fact, the average parameter scores by subwatershed suggest that the difference in composite RSAT scores between the higher and lower scoring subwatersheds is mostly due to differences in scores for the physical in-stream habitat, riparian habitat, and aesthetics parameters.

For most subwatersheds, the water quality and remoteness parameters received consistently 'fair' to 'poor' scores. Poor water quality is expected in a developed watershed because urban hydrology is characterized by large pulses of storm runoff that contain a variety of pollutants, from toxicants to sediment, lower streamflow between storms because of reduced groundwater recharge, and a reduced or absent riparian tree canopy that contributes to increased stream temperature and decreased dissolved oxygen levels—an important indicator of water quality.

The generally low scores for the remoteness parameter reflect the proximity of Arlington residents to most of the County's streams. However, proximity and accessibility do not necessarily mean a stream will be degraded. In fact, residents who live close to and can walk along a stream may be more inclined to protect that stream. Therefore, scores for this parameter should be interpreted with some caution.

Composite subwatershed scores or average parameter values at the subwatershed level present only an aggregate picture of conditions in Arlington streams. RSAT scores for individual stations can indicate particular problem areas, especially in subwatersheds that may otherwise be in good condition. Donaldson Run is the best example of a subwatershed that would have a higher composite RSAT score except for one severely degraded tributary. This tributary, located west of Military Road in Zachary Taylor Park, has been impacted by more recent upstream development and should become a priority for stream restoration. Other subwatersheds in relatively good condition with similarly degraded tributaries include Windy Run, Upper Four Mile Run, and Lubber Run. These tributaries may represent opportunities for stream restoration.

2.3.1.3.1 Importance of impervious and forested areas

The fact that most of Arlington's streams are in 'fair' condition is not surprising, given the degree of development and imperviousness in most of the County. The change in stream conditions induced by development in a watershed is directly related to the impervious surfaces associated with that development.

In fact, a noticeable relationship exists between the RSAT scores for the 16 subwatersheds evaluated and the impervious cover in those watersheds. A plot of percent imperviousness versus RSAT score shows that more than 50 percent of the variability in RSAT scores can be explained by the amount of impervious cover in a subwatershed (Figure 17).

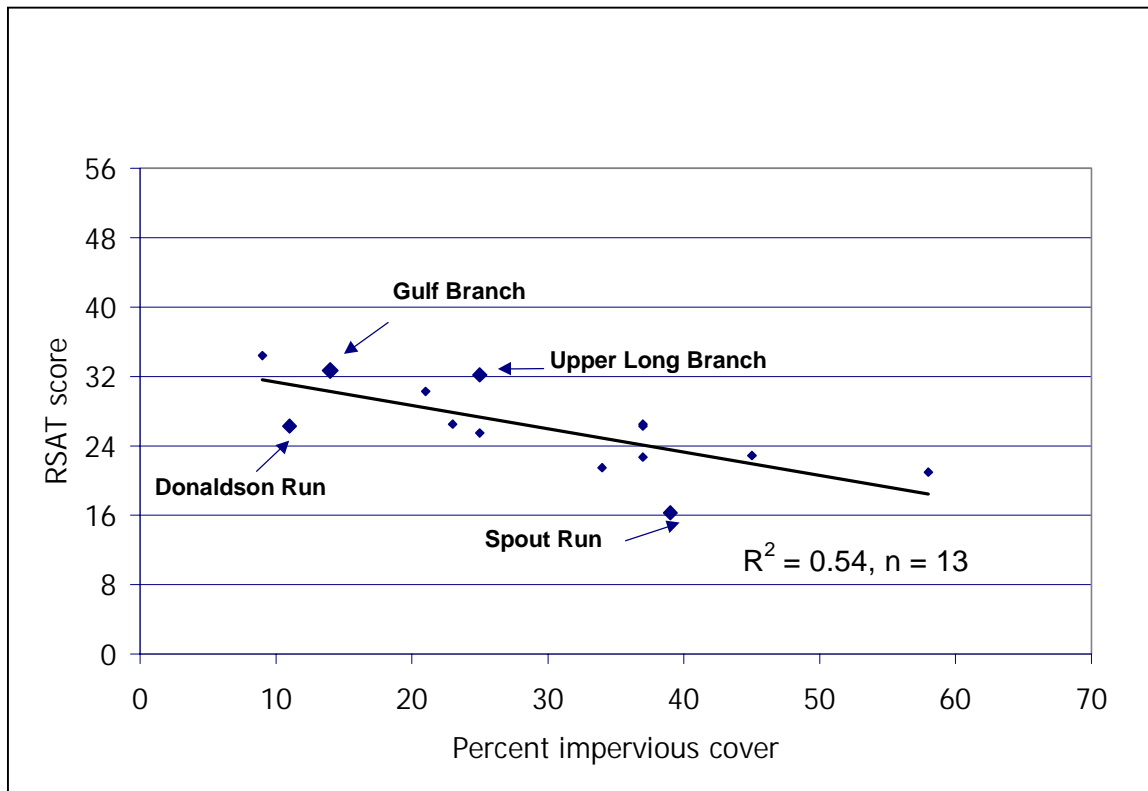


Figure 17. Percent impervious cover vs. RSAT score.

A discernible relationship also exists between the amount of riparian forest cover in a subwatershed and the subwatershed's RSAT score (Figure 18). This is also an expected result because of the well documented importance of riparian buffers to the physical, chemical, and biological health of a stream (EPA, 1996; Dunne and Leopold, 1978). Streams such as Upper Long Branch, Donaldson Run, Windy Run, and Gulf Branch, with 10 percent to 30 percent of their drainage area covered by riparian forest, have relatively high RSAT scores. Even portions of the more extensively developed Four Mile Run watershed are in relatively good condition, probably attributable in part to the stream valley park network.

These relationships are not stronger, however, for several reasons. Other factors, such as the location and type of development, the amount of natural stream channel, and slope are important variables in the hydrologic regime as well as the County's extensive storm water collection infrastructure. Even the amount of riparian forest and impervious cover relative to one another is important. Spout Run, for example, contains approximately 4 percent riparian forest cover, more than some subwatersheds with higher RSAT scores, but it received the lowest RSAT score. There is very little natural stream channel in this watershed, and the nearly 40 percent imperviousness in the drainage area appears to outweigh any benefits of the remaining riparian forest cover.

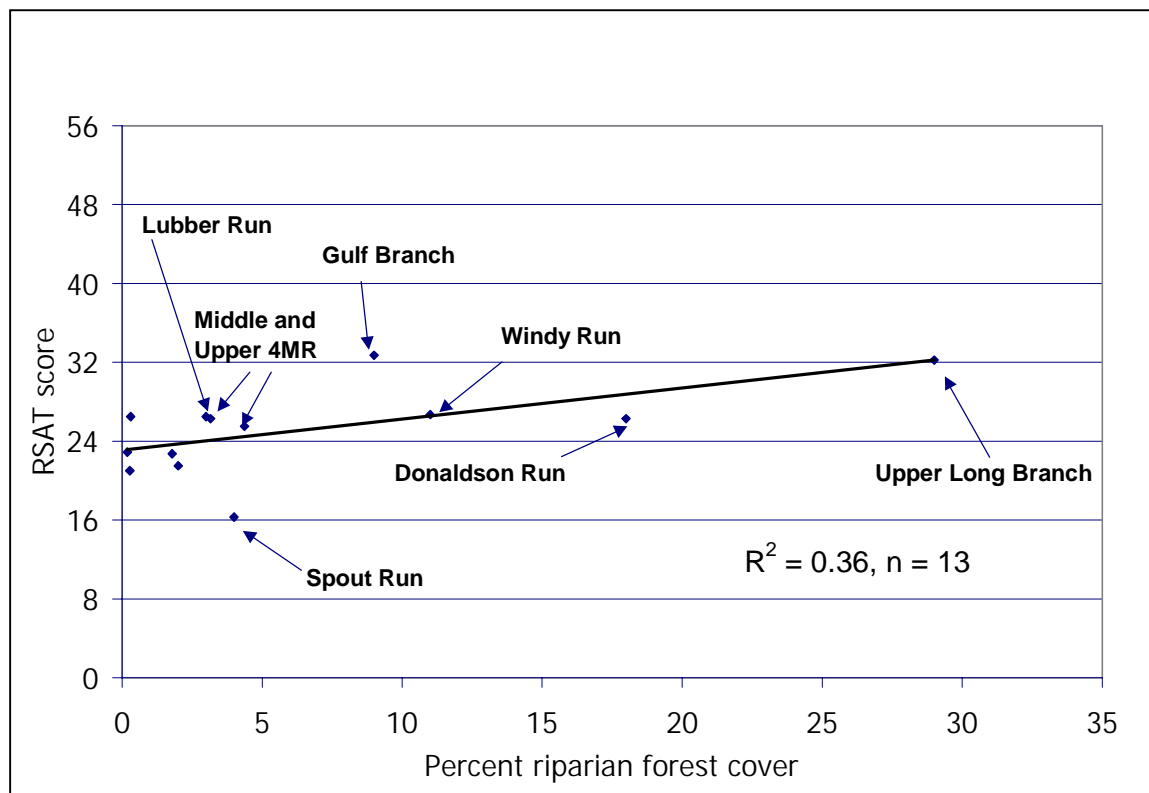


Figure 18. Percent riparian forest cover vs. RSAT score.

2.3.1.3.2 Limitations

There are, of course, limitations to the RSAT approach. It is a screening method designed to help prioritize restoration and watershed protection efforts, not a comprehensive physical, chemical, and biological analysis of stream conditions. In some subwatersheds, ESA evaluated only a few RSAT stations either because some stations did not meet RSAT criteria (e.g., natural stream channel, riffle in reach, etc.), or in a few cases access to the stream was restricted. In some cases, much of the subwatershed occurs in a different jurisdiction. These factors limit the utility of RSAT data in some subwatersheds—for example, Upper Long Branch, Pimmit Run, and Little Pimmit Run.

However, for those subwatersheds with boundaries within Arlington County, ESA evaluated nearly all of the natural stream channels. A low number of stations within a subwatershed, therefore, may itself be an indicator of the impact of development in that subwatershed, rather than an insufficient data set. For example, most of the streams in that subwatershed may have been replaced by storm sewers. Nevertheless, the RSAT data provide a valuable picture of current conditions in Arlington's subwatersheds, and a starting point to begin charting a path towards watershed protection and stream restoration.

The RSAT data suggest that County stream buffer management practices have helped to mitigate the effects of development in some areas, such as portions of Four Mile Run, Lubber Run, and Upper Long Branch. However, development in Arlington has significantly impacted County streams, and even the least developed watersheds like Donaldson Run show some seriously impaired stream reaches.

On the positive side, the macroinvertebrate data collected at the 15 permanent monitoring stations indicate that County streams are not mere lifeless conduits for storm water. There are, in fact, lively aquatic ecosystems. However, because of high flows during storms and repeated pulses of urban pollutants, only a relatively small number of pollution-tolerant species of aquatic organisms can thrive in Arlington's streams. At the same time, water quality in most of the streams surveyed was characterized as poor. A ubiquitous algal and bacterial film covered the streambeds at most stations during the late spring, low flow conditions when ESA and County staff conducted the stream survey. This biological growth is an indication of nutrient enrichment, supporting a variety of pollution-tolerant macroinvertebrates like net-spinning caddisflies (*Hydropsychidae*), midges (*Chironomidae*), and mayflies (*Baetidae*). Nutrient enrichment and other stream pollution can be exacerbated during low flow conditions because pollutants in the water column often become concentrated.

Although ESA did not collect water samples during the inventory, other known water quality problems in County streams include fecal coliform bacteria levels that often exceed state water quality standards. This problem is not unique to Arlington, however. Fecal coliform levels in urban stormwater frequently exceed water quality standards by factors of 50 or more (Schueler, 1999).

Overall, the RSAT study was a screening level analysis of conditions of Arlington County streams over a three-week period during the growing season—it is a starting point for evaluation, discussion, and action. As such, the RSAT inventory data provide a framework to identify protection and restoration priorities, including specific actions that the County can take now, and long-term projects that will require more study.

2.3.2 Land use

Arlington County's geographic information system (GIS) contains a real estate data layer that includes information on land use at the parcel level. EPO analyzed this information to calculate current land uses in each subwatershed, as shown in Table 5 and Figure 19. Streets and highways generally are not included in this analysis because they are not contained in the real estate database as parcels.

Table 5 also shows the amount of vacant, developable land in each subwatershed, defined as parcels with \$0 of improved value in the real estate database (a method suggested by the County's Real Estate Assessments division). However, parcels with a \$0 improved value that also fall under the public, semi-public, government/community facilities category were not considered vacant, since many of these parcels are parks and similar facilities that will remain in their current condition indefinitely. Instead, these parcels were included in the public, semi-public, government/community facilities category.

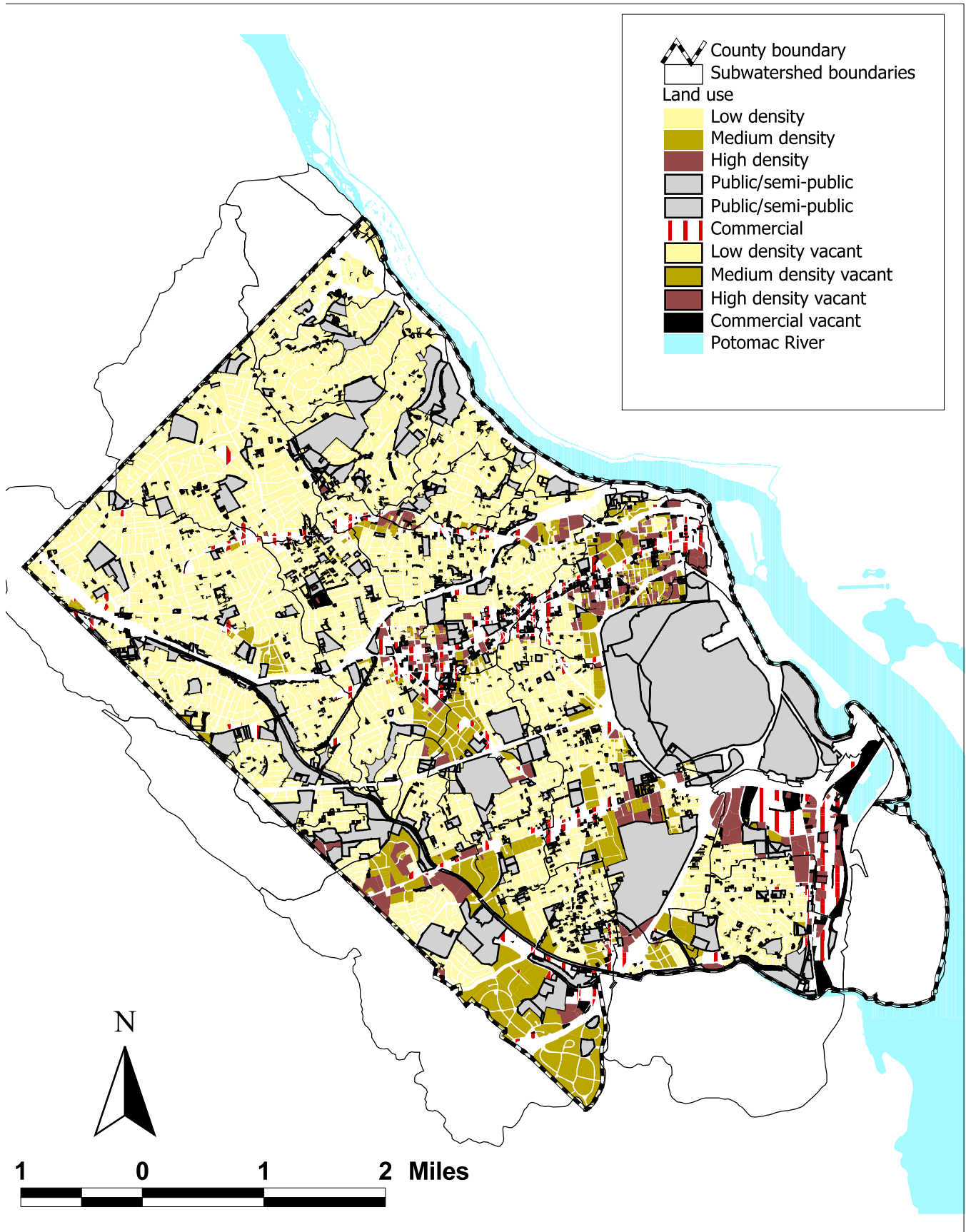
Subwatershed	Low density	Medium density	High density	Public, semi-public, gov't/comm.	Commercial /industrial	Vacant develop-able
Colonial Village/Rocky Run	14.5	23.6	19.9	13.7	19.6	7.3
Doctors Branch	42.5	17.8	2.4	30.1	4.4	2.2
Donaldson Run	56.9		0.2	40.4	0.1	2.0
Gulf Branch	77.9			19.8	0.1	2.0
Little Pimmit Run	80.8		0.1	13.1	2.8	2.5
Lower FMR	43.8	7.0	6.6	24.2	8.5	6.8
Lower Long Branch	35.0	10.5	5.7	40.3	4.4	3.0
Lubber Run	57.3	5.9	3.8	17.1	8.9	4.4
Middle FMR	31.9	32.0	7.4	20.3	4.7	2.5
Pimmit Run	84.5			6.9		4.4
Potomac Direct A	33.1	3.6	4.6	51.0		6.1
Potomac Direct B	68.7			23.5		5.6
Spout Run	56.3	5.8	6.2	14.0	12.3	3.9
Upper FMR	72.3	2.2	0.1	20.0	2.9	1.7
Upper Long Branch	39.2	0.7	7.2	50.5		2.5
Windy Run	74.1	1.1	4.7	16.3	0.5	3.2
County-wide totals	47.3	8.6	4.6	28.8	5.8	3.7

Table 5. Current land uses in 16 subwatersheds

(values expressed as percent of total categorized land area in each subwatershed; values in bold are predominant land use type(s); values may not total 100 percent because of uncategorized parcels with use codes 540 and 640).¹²

¹² Low density category is comprised of the following land use codes in rpedat.dbf (as of 1/00): residential/vacant (510), single-family detached (511), townhouse (512, 513), and side-by-side (514). Medium density category is comprised of multi-family site plan (300), multi-family no site plan (301), apartment parking (310), apartment garden (311), condo garden (613), and condo stacked (616). High density category is comprised of apartment mid-rise (312), apartment high-rise (313), SFD/Apt zone no site plan (530), SFD/Apt zone site plan (531), condo mid-rise (611), condo high rise (612), condo co-op (614), condo commercial (615), and hotel (full service, limited service, lodging, hotel land/other; 411-414). Public, semi-public, government/community facilities is comprised of any use code with exempt field codes 0 (Washington Metropolitan Area Transit Authority), 1 (Arlington County Board), 2 (Commonwealth of Virginia), 3 (Federal Government), 4 (Charitable Organization/Lodge), 5 (Church), 7 (Volunteer Fire Department), 8 (Arlington County School Board), 9 (Northern Virginia Regional Park Authority), A (Embassy), E (Arlington Health Center Commission), F (Private Schools), and S (Arlington Community Services Board); in addition, the following parcels were added to this category for consistency with the General Land Use Plan classifications: parcels with use code 218 (Health Care Facilities), Donaldson Run Recreation Area (rpcmstr # 04011229), Washington Golf and Country Club (03047004, 03061007, 03061010, 03061011, 030361012), Columbia Gardens Cemetery (19039087), and Army/Navy Country Club (32001006); commercial/industrial is comprised of office (101, 110, 111, 112), general commercial (200, 201, 210-219). General commercial/industrial (251-254), SFD/Commercial zone no site plan (520), and SFD/Commercial site plan (521). Use codes 540 (Not valued residential - HOA) and 640 (Not valued condo - HOA) were not categorized. Parcels assigned these two codes comprise approximately 0.14 square miles in land area, or about 0.5% of County land.

Figure 19. Current land use in Arlington County.



2.4 Future land use changes

2.4.1 Zoning, Development, and General Land Use Plan

Arlington County's zoning ordinance and map classify all land according to various zoning districts. Each zoning district permits a certain type and level of development 'by-right.' Beyond the by-right development permitted in each district, certain districts provide public review processes for special exceptions by site plan or use permit that allow greater flexibility in the use, density, and form of development.

The County's zoning represents the legal rights and constraints for existing and future development in each subwatershed. The County's General Land Use Plan (GLUP) is the primary policy guide for the future development of the County. The two work in tandem to provide a guide for future development in the County, with the by-right development process allowing development consistent with zoning.

EPO used the zoning and GLUP data layers in the GIS system to estimate the planned land uses in each subwatershed, as shown in Table 6 and Table 7. The land use categories shown have been aggregated from those provided in the General Land Use Plan^{13,14}. Differences in land use percentages between Table 6 and Table 7 may in part be due to the simplification of land use categories.

¹³ Zoning key: the General Land Use Plan lists zoning codes associated with each GLUP category. GLUP categories have been simplified for this analysis, as described in the next footnote. The zoning codes associated with these simplified categories, as shown in Table 4, are as follows: the low density category is comprised of zoning codes R2-7, R5, R6, R8, R10, R10T, R15-30T, and R20. Medium density category is comprised of zoning codes CO1.0, CO1.5, CO2.5, CR, RA6-15, RA7-16, RA8-18, RA14-26, and RA-H. High density category is comprised of zoning codes CO, RA4.8, RAH3.2, and RC. Public, semi-public, and government/community facilities is comprised of zoning codes PS, S3A, and SD. Commercial/industrial is comprised of zoning codes C1, C1O, C1R, CM, COA, COROSS, CTH, C2, C3, M1, and M2.

¹⁴ General Land Use Plan key: low density category is comprised of the following GLUP categories (as of 12/99): residential low; medium density category is comprised of GLUP categories residential low-medium, residential medium, office/apartment/hotel low and medium, and medium density mixed-use; high density category is comprised of GLUP categories residential high-medium, residential high, office/apartment/hotel high, and high-medium residential mixed use; Public, semi-public, and government/community facilities is comprised of the same GLUP categories; Commercial/industrial is comprised of GLUP categories service commercial, general commercial, service industry, and coordinated mixed use development district.

Subwatershed	Low density	Medium density	High density	Public, semi-public, gov't/comm.	Commercial /industrial
Colonial Village/Rocky Run	13.4	33.1	19.9	20.3	13.3
Doctors Branch	51.1	21.5	0.7	21.0	5.7
Donaldson Run	80.6		0.02	19.3	0.1
Gulf Branch	88.2			11.8	
Little Pimmit Run	88.1	0.01	0.1	9.7	2.0
Lower FMR	46.3	13.4	2.4	21.5	16.5
Lower Long Branch	52.3	7.4	0.6	24.4	5.2
Lubber Run	63.8	6.1	1.7	17.4	10.9
Middle FMR	34.8	38.3	0.1	17.8	8.9
Pimmit Run	72.8			27.2	
Potomac Direct A	16.4	1.9	1.3	77.3	1.2
Potomac Direct B	54.7			45.3	
Spout Run	56.5	10.1	3.3	16.3	13.8
Upper FMR	74.9	2.7	0.1	20.0	2.3
Upper Long Branch	47.6	1.5		50.9	
Windy Run	80.9	5.9	0.2	12.6	0.4
County-wide totals	58.1	11.0	1.0	20.0	5.8

Table 6. Zoning in 16 subwatersheds

(values expressed as percent of total subwatershed area; values in bold are predominant land use type(s); values may not total 100 percent due to rounding).

Subwatershed	Low density	Medium density	High density	Public, semi-public, gov't/comm.	Commercial /industrial
Colonial Village/Rocky Run	12.6	37.4	23.1	22.5	4.4
Doctors Branch	46.4	22.9	0.0	26.6	4.2
Donaldson Run	63.1	0.0	0.0	36.9	
Gulf Branch	82.1	0.0	0.0	17.9	
Little Pimmit Run	87.1	0.2	0.0	11.3	1.9
Lower FMR	44.8	12.0	3.0	26.2	12.8
Lower Long Branch	36.8	17.8	0.4	40.5	4.6
Lubber Run	58.5	15.1	5.2	18.9	2.1
Middle FMR	35.4	39.2	0.0	22.5	3.8
Pimmit Run	69.1	0.0	0.0	30.5	0.0
Potomac Direct A	14.1	2.6	2.5	79.0	0.0
Potomac Direct B	55.0	0.0	0.0	45.1	0.0
Spout Run	54.9	13.0	6.2	20.2	5.6
Upper FMR	72.8	3.0	0.0	22.2	1.9
Upper Long Branch	48.7	0.8	0.0	52.8	
Windy Run	79.2	7.6	0.0	12.7	0.5
County-wide totals	55.1	13.2	1.9	26.1	3.6

Table 7. General Land Use Plan for each subwatershed

(values expressed as percent of total subwatershed area; values in bold are predominant land use type(s); values may not total 100 percent due to rounding).

2.4.2 'Built-out' estimates and future impervious cover

Any plan for watershed management must take into account the 'development future' of the watersheds to be managed so that protection and restoration efforts are sustainable. Because of its density, Arlington County is considered an 'ultra urban' jurisdiction—most of the County is already 'built-out.' The vacant land estimates in Table 5, along with any tour of the County, corroborate that assessment.

Figure 19, Figure 20, and Figure 21 integrate the current and future land use picture by graphing the data in Table 5, Table 6, and Table 7. The figures indicate that current conditions closely match both zoning and the General Land Use Plan and further confirm the built-out nature of the County.

To capture the effect of build-out on impervious cover, a primary determinant of watershed health, EPO estimated the increase in impervious area as a result of build-out in each subwatershed as follows: for each subwatershed, the area of vacant parcels in the low density, medium density, high density, and commercial/industrial categories was multiplied by an impervious estimate for each category, summed, and divided by total subwatershed area (within the County) to estimate a total future imperviousness.¹⁵ Table 8 also shows each subwatershed's 'built-out' condition as 100 percent minus the vacant land estimate in Table 5.

Subwatershed	Current built-out' estimate (%)	Predicted impervious area increase at final built-out condition (%)
Colonial Village/Rocky Run	92.7	3.3
Doctors Branch	97.8	0.8
Donaldson Run	98.0	0.6
Gulf Branch	98.0	0.6
Little Pimmit Run*	97.5	0.6
Lower FMR*	93.2	3.2
Lower Long Branch	97.0	1.0
Lubber Run	95.6	1.9
Middle FMR*	97.5	1.0
Pimmit Run*	95.6	0.6
Potomac Direct A	93.9	0.5
Potomac Direct B*	94.4	0.8
Spout Run	96.1	1.4
Upper FMR*	98.3	0.4
Upper Long Branch*	97.5	0.2
Windy Run	96.8	0.6
County-wide totals	96.7	1.9
*Data only for portion of subwatershed in Arlington County		

Table 8. Percent 'built-out' estimate and predicted impervious area for 16 subwatersheds.

¹⁵ EPO used the County's GIS system to estimate the imperviousness for each of these land use categories as follows: low density, 22 percent, medium density, 43 percent, high density, 77 percent, commercial/industrial, 77 percent (Williams, 1998). The break-out of vacant land by land use type is provided in Table 10 and Table 11.

Like the current and future land use analysis, the lowest built-out estimate for 16 subwatersheds, 93 percent, and the largest predicted impervious area increase, just over 3 percent, also support the 'ultra urban' characterization of Arlington County.

However, an additional and significant factor to consider for predicting future land use and imperviousness, and a factor not fully captured in the above analyses in part because of the simplified land use and zoning categories, is redevelopment, since many parcels in Arlington are zoned for higher densities, or could be rezoned for higher densities, than the current use. As a result, redevelopment in the County could result in considerably higher impervious cover in the subwatersheds in which it is likely to occur.

According to the County's Department of Economic Development (DED), there are approximately 80 sites in the County with good potential for commercial redevelopment. These sites are located in Ballston, Virginia Square, Clarendon, Courthouse, Rosslyn, Crystal City, Pentagon City, and Shirlington, as well as along Columbia Pike, Lee Highway, and Route 7 (Arlington County DED, 1999; William Thomas, CPHD, personal communication). And, as Arlington's aging housing stock begins to be replaced with larger homes, incremental increases in site coverage on single-family lots will likely occur County-wide.

In addition, existing and future development data are needed for the portions of the subwatersheds in Arlington County that extend into Fairfax County, Alexandria, and Falls Church to fully characterize these subwatersheds (e.g., Upper Long Branch, Pimmit Run, and Lower Four Mile Run).

2.5 Subwatershed goals

The stream inventory data and current and future land use analyses, along with data provided in the County's Storm Water Master Plan (SWMP), provide the framework for overall management goals for each subwatershed that are achievable goals. The SWMP, a required element of the County's Comprehensive Plan completed in 1996, relies heavily on research conducted by the Center for Watershed Protection (CWP).

CWP identifies three major categories of watersheds based on impervious cover, described as 'sensitive' (○), 'impacted' (◐), and 'non-supporting' (●) (Caraco et al., 1998).

- Watersheds with less than 11 percent impervious cover are characterized by stable channels and excellent biodiversity and water quality (○);
- Between 10 and 25 percent impervious cover, watersheds begin to show unstable channels and exhibit good to fair biodiversity and water quality (◐). Some streams in this category have good potential for restoration because of impervious cover towards the lower end of this range and/or good opportunities for BMP retrofits that will improve the hydrology and water quality of the stream (○+); and
- Beyond 25 percent imperviousness, most indicators of stream quality, such as aquatic diversity, water quality, and habitat, shift to a poor condition because of high storm flows, channel erosion and sedimentation, and elevated levels of bacteria, nutrients, and metals (●).

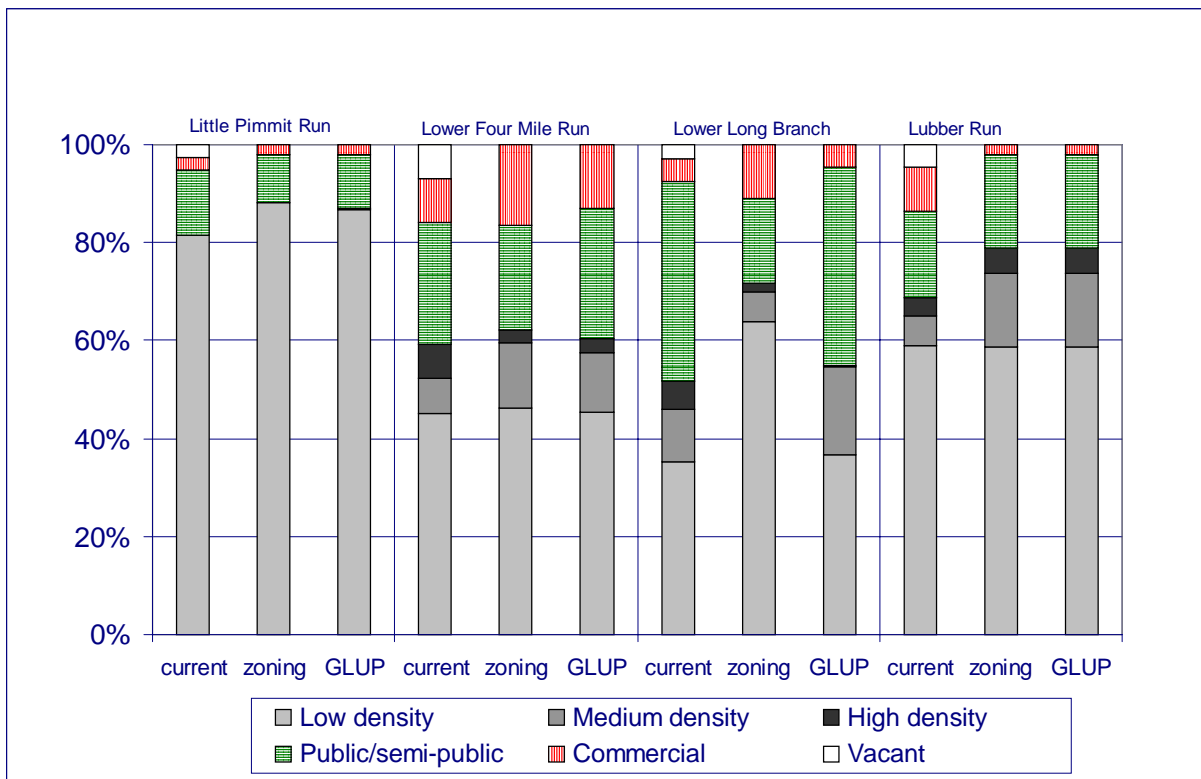
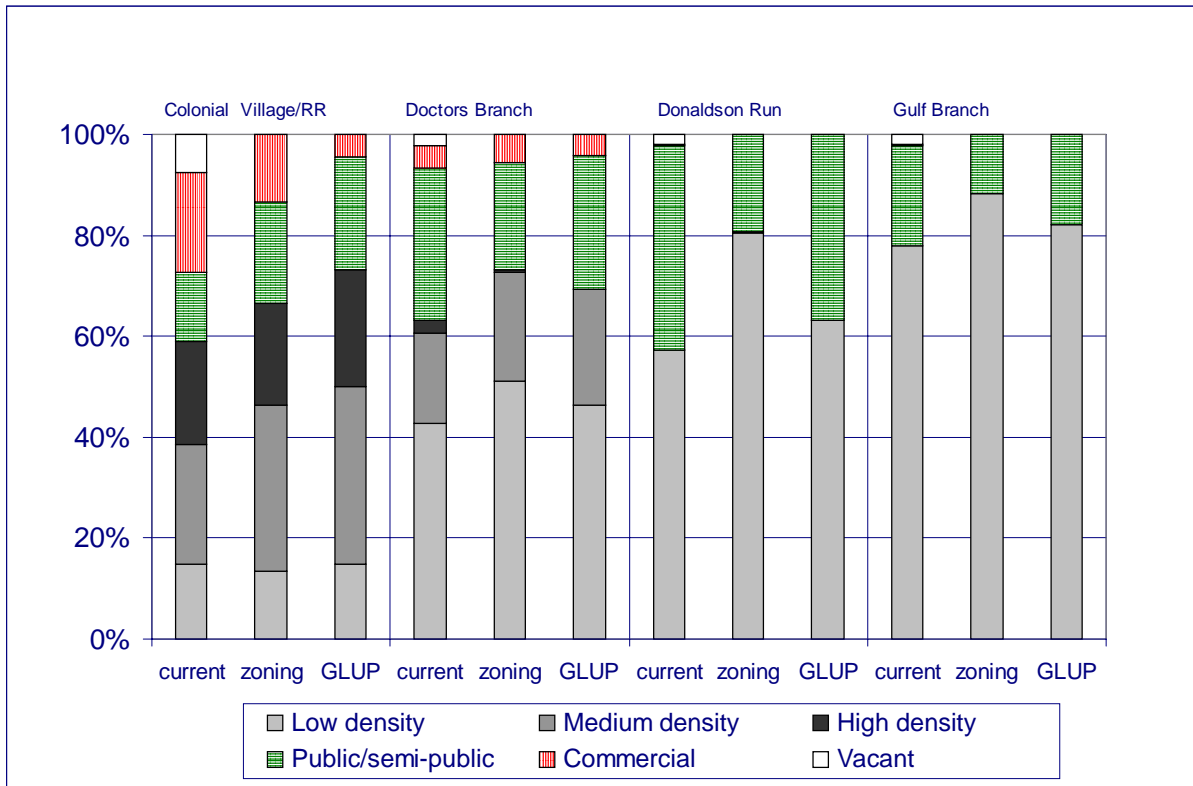


Figure 20. Current land use, zoning, and General Land Use Plan for eight subwatersheds.

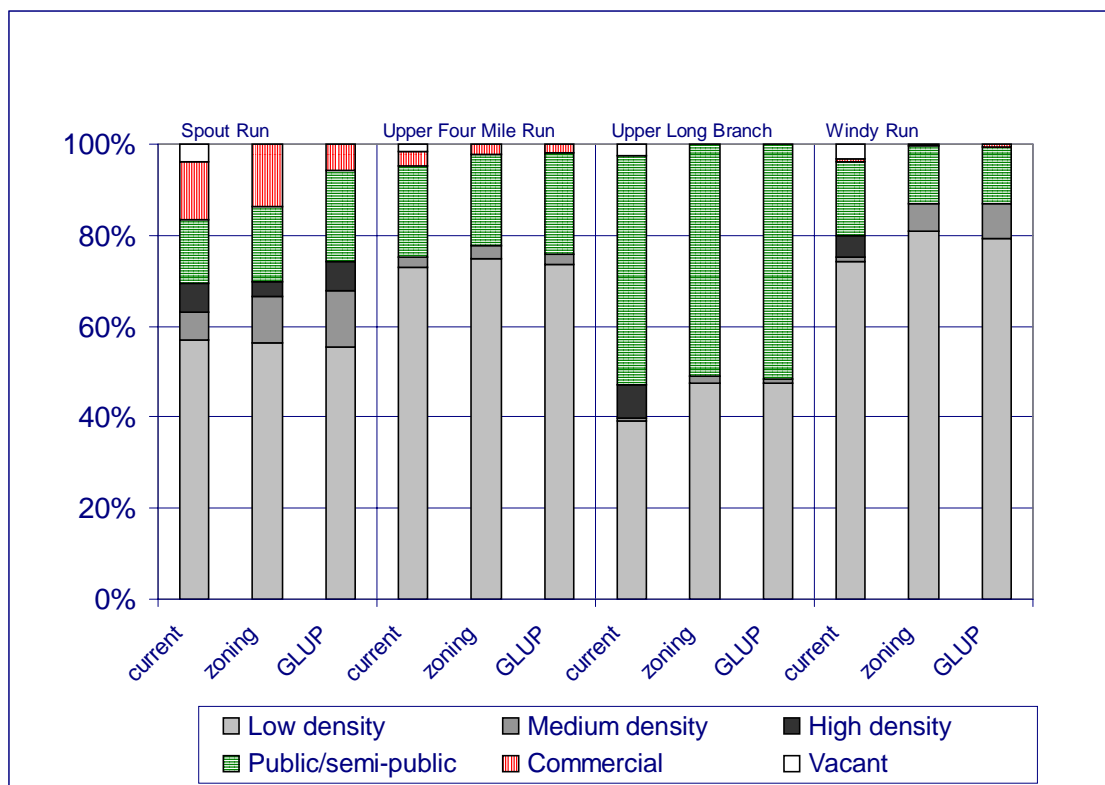
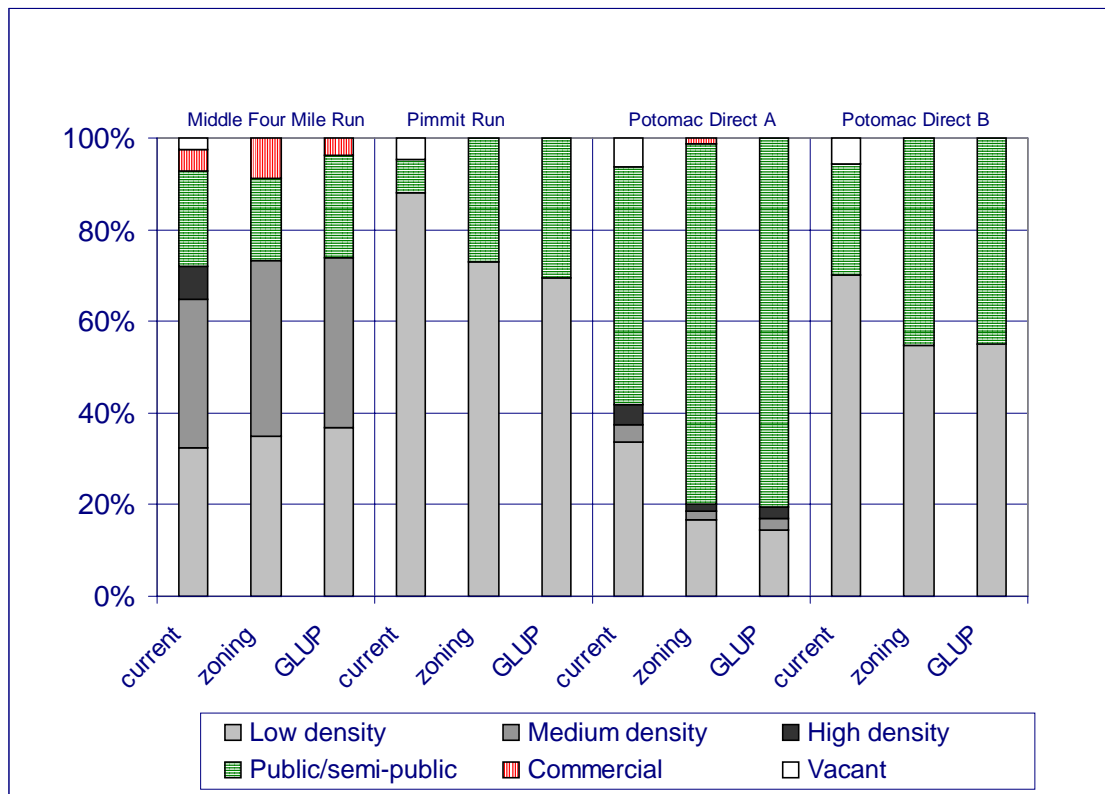


Figure 21. Current land use, zoning, and General Land Use Plan for eight subwatersheds.

Building on CWP's work, the SWMP recommends three management goals for County subwatersheds (for comparison purposes in Table 9, these three goals also are identified by the symbols ○●●):

- Stream restoration (○): watersheds with natural channels and less than 25 percent imperviousness;
- Water quality improvements (●): streams in subwatersheds with more than 25 percent imperviousness which flow through areas of moderate imperviousness and little forest or open space and where habitat restoration is difficult; and,
- Flood damage reduction (●): watersheds with no natural drainage, regardless of imperviousness (along with some water quality measures to improve receiving waters). (Arlington County DPW, 1996)

For each of the 16 subwatersheds evaluated using the RSAT technique, Table 9 integrates the RSAT results (○ = Good, ● = Fair, ● = Poor) and the CWP and SWMP management categories to develop an overall watershed management category. The table lists the 16 subwatersheds evaluated with the RSAT analysis, with the 32 subwatersheds discussed in the SWMP as a subset of these 16 subwatersheds.

Table 9 suggests that the RSAT data are consistent with the management goals of the SWMP. The SWMP recommends restoration activities in watersheds that also have the highest RSAT scores—Gulf Branch, Upper Long Branch, and Windy Run. Low RSAT scores in one degraded tributary of Donaldson Run reduced the composite RSAT score for the subwatershed. However, the low imperviousness of this subwatershed makes it a good candidate for stream restoration, especially in the degraded tributary in Zachary Taylor Park.

The table also confirms the importance of imperviousness as an indicator of stream health (supported by the plot of percent imperviousness versus RSAT score in Figure 17) as well as whether or not the restoration and management priorities identified by the SWMP and RSAT analyses are worth considering. In general, restoration activities in streams with more than 25 percent impervious may not be sustainable.

Because no subwatershed in Arlington County has less than 10 percent impervious cover, CWP's 'sensitive' category does not really apply to County streams. At the same time, although many Arlington subwatersheds have more than 25 percent impervious cover, 'non-supporting' may not be the most descriptive term because many of these streams do support viable aquatic ecosystems—albeit ones often dominated by pollution-tolerant species.

Therefore, recognizing that all of the County's streams have been affected by development, this plan uses the following qualitative descriptions of management categories for Arlington's urban subwatersheds: 'least impacted' (○), 'more impacted' (●), and 'most impacted' (●).

Least impacted subwatersheds (○): Gulf Branch and Donaldson Run are probably the best candidates for stream restoration in Arlington County. The management goals for these subwatersheds include:

- reducing the flow rate and volume of stormwater runoff;
- reducing stormwater pollution, especially sediment, nutrients, and bacteria (consistent with overall Chesapeake Bay Agreement and Potomac Tributary Strategy goals as well as concerns over water quality violations for bacteria in urban streams);
- stabilizing eroded stream channels;
- improving in-stream and riparian habitat;
- improving the diversity of the macroinvertebrate community;
- expanding stream valley parks; and
- improving aesthetic conditions.

(based on Caraco et al., 1998)

More impacted subwatersheds (●): Because of the higher level of impervious cover in Little Pimmit Run, Lower Long Branch, and Windy Run, management goals for these subwatersheds include:

- preventing further increases in the flow rate and volume of stormwater runoff;
- reducing stormwater pollution, especially sediment, nutrients, and bacteria;
- stabilizing eroded stream channels;
- preventing degradation of in-stream and riparian habitat;
- maintaining the diversity of the macroinvertebrate community;
- expanding stream valley parks; and
- improving aesthetic conditions.

(based on Caraco et al., 1998)

Most impacted subwatersheds (●): Because of the highest level of impervious cover in Lower Long Branch, Doctors Branch, Spout Run, Lubber Run, Colonial Village/Rocky Run, and Upper, Middle, and Lower Four Mile Run, the management goals for these subwatersheds include:

- minimizing increases in the flow rate and volume of stormwater runoff;
- reducing flooding;
- minimizing pollutant loads to downstream waterbodies (Four Mile Run, Potomac River), especially sediment, nutrients, and bacteria;
- expanding stream valley parks; and
- improving aesthetic conditions.

(based on Caraco et al., 1998)

However, the stream inventory and SWMP suggest portions of 'more impacted' and 'most impacted' subwatersheds may be suitable for restoration projects (e.g., Four Mile Run Upper Mainstem 2). The next section will discuss such projects, as well as other specific actions to implement in each subwatershed.

Subwatershed	Qualitative RSAT rating/ Impervious cover		Storm Water Master Plan category		CWP category	Watershed management category Least impacted=○ More impacted=● Most impacted=●
Colonial Village, Rocky Run	●	58%	Rocky Run	●	●	●
			Colonial Village	○		
			Rosslyn	●		
Doctor's Branch	●	34%		○	●	●
Donaldson Run	●	11%		○	●+	○
Gulf Branch	○	14%		○	●+	○
Little Pimmit Run*	●	23%	Mainstem	○	●	●
			East	○		
			West	●		
Lower Four Mile Run*	●	45%	Lower Mainstem	○	●	●
			Virginia Highlands	○		
Lower Long Branch	●	37%	Lower Long Branch	○	●	●
			Arlington Branch	○		
Lubber Run	●	37%		○	●	●
Middle Four Mile Run*	●	37%	Nauck Branch	●	●	●
			Lucky Run	●		
			Bailey's Branch	○		
			Middle Mainstem	○		
Pimmit Run*	○	9%		NA	NA	NA
Potomac Direct (A)	○	NA		NA	NA	NA
Potomac Direct (B)*	●	NA		NA	NA	NA
Spout Run	●	39%		○	●	●
Upper Four Mile Run*	●	25%	Upper Mainstem 1	○	○	●
			Upper Mainstem 2	○		
			Crossman Run	●		
			Westover Branch	●		
Upper Long Branch*	○	25%		○	○	○
Windy Run	●	21%		○	○	○

Table 9. Qualitative RSAT ratings, Storm Water Master Plan and CWP management categories, and overall management categories for County subwatersheds.

*These subwatersheds are those with drainage areas that include areas outside of Arlington County. Land use and stream inventory data are lacking for the portion of these subwatersheds in Fairfax County, Alexandria, and Falls Church. As a result, management goals for these subwatersheds should be interpreted with some caution.

NA = As described in Section 1.5, the majority of the Pimmit Run drainage area and stream channel is outside of Arlington County. Therefore, there is not enough information to categorize the entire subwatershed. Also, impervious cover data are not currently available for the Potomac Direct (A) and Potomac Direct (B) subwatersheds, and both subwatersheds actually consist of small, separate drainage areas. Therefore, this plan does not provide an overall management category for these subwatersheds.

2.6 Watershed management recommendations

Implementation of this watershed management plan is divided into the same five components introduced in the County management practices section of this document. These include:

- 1) Addressing the sources of stormwater runoff and dry weather pollution (existing and new development, point sources, illegal discharges);
- 2) Implementing and maintaining BMPs to control stormwater pollution;
- 3) Maintaining stormwater infrastructure;
- 4) Managing, monitoring, and restoring streams and buffers; and
- 5) Implementing pollution prevention and watershed education initiatives.

The paragraphs below describe County-wide and subwatershed-specific approaches to carrying out these components.

2.6.1 Sources of stormwater runoff and dry weather pollution

2.6.1.1 County-wide

In mostly built-out Arlington County, existing development, rather than new development or redevelopment, is responsible for most of the runoff generated during storms. Runoff from this development, although regulated under the County's MS4 permit, can be controlled at or near the source if: a) impervious cover is 'disconnected' so that effective imperviousness is reduced and runoff is less concentrated; or b) if a BMP retrofit or other water quality/quantity reduction measure is employed. There may be only limited opportunities to disconnect impervious cover on a County-wide scale, although such actions should be explored and encouraged, particularly in older residential areas where downspouts connect directly to the storm sewer network. The rest of the recommendations for addressing runoff from existing development are contained in Section 2.6.2, 'Stormwater BMPs, BMP retrofits, and maintenance.'

For new development, redevelopment, and construction that does occur in Arlington County, the County ordinances regulating such activities (Stormwater Detention, Chesapeake Bay Preservation, Erosion and Sediment Control) should be enforced as strictly as possible. Without strong enforcement, there are few, if any, incentives for developers to comply with the provisions of these ordinances.

In addition, there are a number of vacant, developable parcels in the County that overlap Resource Protection Areas¹⁶ (RPAs) delineated under the Chesapeake Bay Preservation Ordinance. Although PRCR's mission is to meet the fast-growing recreational needs of the County, PRCR believes that it makes sense to place those parcels required for resource protection among the County's land purchasing priorities in addition to those purchased for active recreation. Such efforts should be coordinated with DPW's floodplain mapping staff to include parcels also subject to flooding. To initiate discussion of this issue, DES and DPW should produce a map showing property boundaries, vacant parcels, RPA boundaries, and the boundaries of the 100-year floodplain.

2.6.1.1.1 Stormwater management program

The County's Stormwater Detention Ordinance, enacted County-wide in 1982, pre-dates Virginia's Stormwater Management Act of 1990. As a result, the State does not consider the ordinance a local stormwater management program as defined by state law and regulation (Arlington County DPW, 1996).

¹⁶ According to Section 61-6 of the County's Chesapeake Bay Preservation Ordinance, the RPA includes i) tidal wetlands and tidal shores, iii) nontidal wetlands contiguous to tidal wetlands or tributary streams, iii) tributary streams, and iv) a 100-foot vegetated buffer located adjacent to and landward of i) and ii) and along both sides of any tributary stream.

Virginia revised its stormwater management regulation (4 VAC 3-20-10 et seq.) in March 1998 to make the stormwater programs of the Department of Conservation and Recreation (DCR), the Department of Environmental Quality (DEQ), and the Chesapeake Bay Local Assistance Department (CBLAD) consistent, as well as to provide flexibility for local governments implementing stormwater management programs.

The revised State regulations allow localities to address water quality, flooding, and stream channel erosion from new development/redevelopment, to develop watershed-wide stormwater plans which can also address runoff from existing development through regional BMPs, and to require stormwater management plans for proposed development projects. These activities are consistent with the goals of this Watershed Management Plan.

In particular, the revised regulations eliminate the previous explicit requirements to control runoff for the 2-year storm from the developed site at pre-developed flow rates (the 'flooding' section of the new regulations requires control of the 10-year storm at pre-developed flow rates). Instead, the new regulations require that properties and streams downstream of a development project must be protected from erosion and damage due to increases in the volume, velocity, and peak flow rate of stormwater runoff.

In lieu of controlling 2-year floods, Virginia's revised Stormwater Management regulations include provisions for localities to require up to 24-hour extended detention of runoff from the 1-year event, releasing this runoff at the pre-developed 1-year flow rates. This extended detention can decrease the flow rate and velocity of runoff from a developed site enough to offset the increases in volume, frequency, and duration of the runoff—especially increases in the frequency of bankfull flows¹⁷ (Virginia DCR, 2000).

However, channel erosion resulting from site runoff may still occur and is addressed by Minimum Standard 19 (MS-19) of the State's Erosion and Sediment Control regulations (4 VAC 50-30-40.19), which provides criteria for the analysis of the downstream channel, as well as options for cases where the channel has been determined to be inadequate to convey flows from the site or where increases in the volume, velocity, and peak flow rate will result in channel erosion. (Virginia DCR, 2000).

Earlier this year, Virginia DCR published Technical Bulletin No. 1 (TB-1), Stormwater Management and Erosion and Sediment Control Program Erosion Control Policy Guidance, which provides guidance for implementing MS-19 criteria, along with criteria in the state's Stormwater Management regulations, for stream channel erosion control (Virginia DCR, 2000).

Further, TB-1 provides guidance for the Ultimate Development Conditions provisions of the State's Erosion and Sediment Control and Stormwater Management regulations (4 VAC 50-30-40.19.j and 4 VAC 3-20-60.H). These provisions require consideration of the hydrologic impacts of an entire development project, not just individual lots or parcels, and the TB-1 guidance extends these provisions to include entire watersheds (Virginia DCR, 2000).

Arlington County's Storm Water Detention Ordinance controls runoff at the 10-year pre-development rate but generally does not control runoff for the 2-year or 1-year post-development storm because the release orifice from the detention structure is too large. The ordinance also supercedes MS-19 for several

¹⁷ In undeveloped watersheds, hydrologists consider the 1.5- to 2-year flood as the channel-forming, or 'bankfull' flood. Bankfull flows are flows that completely fill a stream channel to the top of the bank, and these flows control the shape and form of stream channels through erosion and sediment deposition (Schueler, 1987). After development, the frequency of bankfull flows increases.

reasons, including the Four Mile Run flood control agreement. However, MS-19 can be applied in Arlington County when stormwater detention requirements are waived and runoff from a site discharges directly to a stream channel or swale.

Although the County's Stormwater Detention Ordinance focuses strictly on peak flow reduction for the 10-year and 100-year storm events, Virginia law does not require Arlington County to promulgate a new local stormwater management ordinance consistent with the revised, more comprehensive State regulation because the County's ordinance pre-dates the state law. The County should, however, weigh several arguments in determining whether to revise the Storm Water Detention Ordinance to create a broader 'Storm Water Management Ordinance':

Arguments *for* revising the County's Stormwater Detention Ordinance:

- Since many parcels in Arlington are zoned for higher densities, or could be rezoned for higher densities than the current use, redevelopment in the County could result in considerably higher impervious cover and further stream degradation in the subwatersheds in which it is likely to occur (see Section 2.4, 'Future land use changes'). Such development already triggers the existing Storm Water Detention Ordinance, and if the County revised the ordinance, such development would be required to implement water quantity and quality controls.
- The 10-year flood controls required by the existing Stormwater Detention Ordinance are based on storm sewer capacity, not stream channel impacts.
- The controls required by the County's Stormwater Detention Ordinance do not reduce the total volume of surface water runoff from a given site and often provide few water quality benefits. More surface water runoff means lower groundwater recharge, which in turn contributes to degraded baseflow water quality in streams.
- If, as the stream inventory data suggest, many of the County's stream channels have reached or are approaching equilibrium with existing development, the cumulative increase in flows in a given watershed from future development projects could negatively impact stream channels and stream habitat.
- Where runoff from a development project discharges to a tributary of Four Mile Run (rather than the mainstem), stormwater controls that protect tributary stream channels may be more desirable than controlling for peak flows downstream. Indeed, the Four Mile Run flood control program should be evaluated for consistency with the 'maximum extent practicable' provisions of the County's MS4 permit.
- For subwatersheds in the Potomac drainage, especially Gulf Branch, Donaldson Run, and Windy Run, controlling for 1-year or 2-year post-development flows in addition to the 10-year post-development flood could provide better protection for these relatively sensitive stream channels—especially on a cumulative level.
- This watershed management plan addresses many of the areas covered by the state stormwater regulation but does not have the legal authority of an ordinance, especially specific stormwater runoff requirements for development/redevelopment projects. The County's MS4 permit does provide overall legal authority for stormwater management but not with the specificity of a local stormwater ordinance requiring conditions for site plan approval.

Arguments *against* revising the County's Stormwater Detention Ordinance:

- In a built-out jurisdiction such as Arlington, the effort to develop and implement a revised stormwater management ordinance that addresses only new development and redevelopment may not be worth the stream channel and water quality benefits. A revised ordinance would have to be consistent with the state regulations, and the County may not have sufficient staff or resources to develop and administer such an ordinance.
- In Arlington County, most development/redevelopment projects will be located away from a natural stream channel and runoff from these sites will be conveyed to the channel by storm sewers. By the time runoff from the new site reaches a stream channel through the storm sewer network, this runoff will be combined with runoff from many other sites and streets that have existed for many years. As a result, the requirements of the new State stormwater regulations to evaluate stream channel impacts from new development/redevelopment may seem impractical for Arlington, unless the new site is very large and its impacts on a stream channel are significant.
- MS-19 already applies to Arlington County. Applying this standard with the enhancements offered in Virginia DCR's TB-1, especially extended detention, should improve stream channel protection from new development/redevelopment without the need to revise the County's Stormwater Detention Ordinance. The revised state stormwater management regulations do allow localities to adopt more stringent channel analysis criteria and design standards to reduce channel erosion to the maximum extent practicable (Virginia DCR, 2000). Arlington County should begin consulting and applying the TB-1 guidance during the site plan review process. The guidance provides important tools to achieve many of the goals of this Watershed Management Plan.
- Requiring extended detention within the Four Mile Run watershed may conflict with the requirements of the Four Mile Run flood control program by synchronizing the release of runoff from new development/redevelopment. And, controlling for 1-year or 2-year post-development flows in addition to the 100-year post-development flood may not be practical.
- Detention of the 1-year or 2-year flood with discharge from a detention facility at pre-developed runoff rates still results in an increased *frequency* and *duration* of the bankfull flood, with the potential to erode stream channels and degrade stream habitat (Strecker and Reininga, 2000).

Before Arlington County begins to consider the above issues in deciding whether to revise the Storm Water Detention Ordinance, for purposes of consistency, the County should first complete its review and revision of the Chesapeake Bay Preservation Ordinance (see next section).

2.6.1.1.2 Chesapeake Bay Preservation Ordinance

Arlington County is already in the process of amending its Chesapeake Bay Preservation Ordinance (CPBO). The Chesapeake Bay Task Force appointed by the County Board began meeting in January 1999. This citizens' task force is charged with reviewing and making recommendations for updating the CBPO in accordance with the proposed changes to the State's Chesapeake Bay Preservation Act, comments received from the Chesapeake Bay Local Assistance Department on the County's ordinance, and the County's experience administering the ordinance since its adoption in 1992. The Task Force submitted a final draft of the report to the County Board in April 2000. Following a work session with the County Board in July 2000 and public review of the final report, the County Board instructed staff to amend the Chesapeake Bay Preservation Ordinance. This effort began in late 2000.

Issues addressed by the Task Force include designation of Resource Protection Areas (RPAs) (including remapping of County streams), development in RPAs (including whether the 2,500 square foot threshold that currently triggers County review of proposed activities within the RPA is appropriate), development

in Resource Management Areas¹⁸ (including performance criteria for site design), and the Source Control Fund (including the rate charged to developers, when contributions should be encouraged, and the use of funds).

2.6.1.1.3 BMP retrofits

Independent of potential revisions to the Storm Water Detention Ordinance and the pending revisions to the Chesapeake Bay Preservation Ordinance, Arlington County should emulate the 'Targets of Opportunity' program of the City of Alexandria. The objective of this program is to address runoff from existing development not directly regulated by the Chesapeake Bay Preservation program to further reduce pollutants reaching the bay and its tributaries. To achieve this objective, the program identifies potential sites for urban stormwater BMP retrofits, stresses early exploration of retrofit options with site owners/developers, and strives to implement BMP retrofits wherever opportunities arise to do so.

To date, the seven significant BMP retrofits approved under Alexandria's program treat runoff from more than 1,000 acres. These retrofits are primarily regional or onsite ponds and most have been designed and built by developers (Bell and Champagne, 1998). The City of Alexandria estimates that these facilities are meeting a significant portion of the urban retrofit pollution reduction targets for the Virginia Shenandoah and Potomac River Basins Nutrient Reduction Strategy.¹⁹

2.6.1.1.4 Utilities Ordinance

The County also has a Utilities Ordinance (Chapter 26 of the County Code) which states:

It shall be unlawful for any person to discharge any sewage, chemicals, oils, tars, toxic or poisonous wastes or any substance likely, in the opinion of the County Manager, to have an adverse effect on the storm drains or open watercourses or to endanger life or limb or which may constitute a public nuisance into any storm drain or open stream.

To improve the County's compliance with its MS4 permit, this ordinance should be amended to define the term 'discharge' (i.e., direct dumping into a storm drain as well as runoff from washing industrial equipment and property) and to define 'wastes' and 'substance' in a regulatory context consistent with statutes such as the federal Clean Water Act. The County has not used this ordinance for broad environmental protection purposes, in the past. Enforcement of the existing ordinance raises concerns about staffing and authority that need to be resolved before revising the ordinance.

2.6.1.1.5 Septic Tanks

Staff recommends two strategies to address the remaining septic tanks in Arlington County. First, existing septic tanks need to be well maintained and operating as efficiently as possible. Under the County's Chesapeake Bay Preservation Ordinance, all properties within the County served by septic tanks are required to have their tanks pumped out by a licensed hauler at least once every five years.

Since the adoption of the Chesapeake Bay Preservation Ordinance in 1992, the County has not taken steps to enforce this requirement, primarily due to an unclear delineation of authority among County agencies and lack of staff resources. DES should work closely with the County's Department of Human Services – Environmental Health Division to define appropriate authority.

¹⁸ According to Section 61-6 of the County's Chesapeake Bay Preservation Ordinance, a Resource Management Area includes all areas within the County not designated as RPAs.

¹⁹ Source: <http://www.ci.alexandria.va.us/solidwaste/teswbst.html>. Virginia's Shenandoah and Potomac River Basins Nutrient Reduction Strategy is part of the state's implementation of the Chesapeake Bay Agreement of 1987, which included a commitment to reduce the controllable loads of phosphorus and nitrogen entering the Bay by 40 percent by the year 2000. The signatories to the 1987 agreement released a draft revised agreement in 2000.

It is recommended that DES take primary responsibility for notifying residents on septic tanks as soon as possible to inform them of the pump-out requirement. The notice should provide a deadline to accomplish the pumping, or require that the property owner provide documentation that the tank has been pumped out within the past five years.

The County should also reexamine the possibility of extending sewer service to any property served by a septic tank. Particularly in cases where topography does not present an obvious technical or economic barrier, County staff should determine what it would cost to connect these properties to the County's sanitary sewer system. The County should also evaluate possible long-term funding for the required infrastructure, and the possibility of using Source Control Funds or other grant funding to provide an incentive for connection.

2.6.1.2 Subwatershed strategies

2.6.1.2.1 Least impacted subwatersheds (○) and More impacted subwatersheds (●)

Although Little Pimmit Run, Upper Long Branch, and Windy Run are categorized as 'More impacted' subwatersheds because they contain higher impervious cover and exhibited lower overall RSAT scores than the 'Least impacted' Gulf Branch and Donaldson Run subwatersheds, the similar current and predicted land uses for these five subwatersheds suggest similar strategies for addressing remaining development.

Because of the relatively good condition of most of the streams in these subwatersheds, particular attention should be paid to the development planned in each subwatershed. This potential development, although it will comprise a small portion of each subwatershed, could negatively impact the nearest stream channels without adequate runoff controls. In addition, in Little Pimmit Run and Windy Run, total built-out imperviousness in each subwatershed is predicted to remain below 25 percent. However, redevelopment projects have the potential to increase impervious cover beyond this threshold. For Upper Long Branch, impervious cover and stream conditions in the portion of the subwatershed outside of Arlington County should be determined to refine management approaches in this subwatershed.

Predicted uses for vacant land and estimated built-out impervious cover in these five subwatersheds is summarized in Table 10.

Subwatershed	Vacant, developable land	Predicted use for vacant land	Estimated built-out imperviousness
○ Gulf Branch	2.0%	76% low density 24% commercial	14.6% (0.6% increase)
○ Donaldson Run	2.0%	81% low density 19% commercial	11.6% (0.6% increase)
● Little Pimmit Run	2.5%	84% low density 16% commercial	23.6% (0.6% increase)
● Upper Long Branch	2.5%	90% low density 10% commercial	25.6% (0.6% increase)
● Windy Run	3.2%	99% low density 1% medium density	21.6% (0.6% increase)

Table 10. Vacant land and estimated built-out impervious cover in ○ and ● subwatersheds.

Recommendations for managing runoff from new development/redevelopment:

- Strictly implement provisions of Chesapeake Bay Preservation Ordinance; minimize the number of exceptions granted;
- Increase inspection frequency and enforcement under Erosion and Sediment Control Ordinance;

- Minimize or eliminate waivers granted under Storm Water Detention Ordinance;
- Encourage reduced impervious cover and water quality BMPs during the site plan review process;
- Purchase vacant land and encourage conservation easements for property owners to preserve open space for parkland and/or stormwater retrofits; and
- Disconnect impervious cover from new development (and existing development) as much as possible to maintain or even reduce current levels of effective imperviousness in these subwatersheds.

2.6.1.2.2 Most impacted subwatersheds (●)

Impervious cover ranges from 25 to 58 percent in the Lower Long Branch, Doctors Branch, Spout Run, Lubber Run, Colonial Village/Rocky Run, Upper Four Mile Run, Middle Four Mile Run, and Lower Four Mile Run subwatersheds. At the same time, all of these subwatersheds, except for Upper Four Mile Run, contain County-targeted, high-density development areas in the Rosslyn-Ballston, Columbia Pike, Pentagon City, and Jefferson Davis corridors. As a result, management of subwatersheds that include these corridors should focus on encouraging further concentrated development within these corridors and controlling runoff quality and quantity from this development, rather than reducing future impervious cover in each subwatershed as a whole. Table 11 shows a maximum increase of 3.3 percent in estimated 'built-out' impervious cover in these subwatersheds.

In addition, with the exception of the Spout Run and Colonial Village/Rocky Run subwatersheds, all of the subwatersheds in this category are located within the larger Four Mile Run watershed. Stormwater management in this subwatershed is governed by the Four Mile Run flood control program. Therefore, development in the Four Mile Run watershed is subject to stringent peak flow controls. However, providing stormwater detention at this level still does not eliminate the problems of increased runoff volume and duration of peak flows, and decreased groundwater recharge, from the increased impervious surfaces that accompany development.

Recently, a proposed development project at Potomac Yards in south Arlington has prompted questions about the conditions imposed by the more than 25-year old Four Mile Run flood control program. In particular, a working group charged with looking at the open space and riparian features of the proposed project has begun to explore whether the channel has more than adequate capacity to convey the 100-year flood and if riparian restoration above the 100-year flood elevation is possible. In March 2000, Arlington County and the City of Alexandria sent a letter to Congressman Moran requesting federal funding to reevaluate the flood control project, including current and future channel capacity, channel and riparian restoration, preliminary urban design elements for waterfront revitalization, and upstream measures needed throughout the Four Mile Run watershed to maintain the long-term viability of the flood control project. Congress approved a special appropriation of \$1 million and work on this project is expected to begin early in 2001.

Recommendations for managing runoff from new development/redevelopment

- Continue to implement County land-use and economic development policies to encourage further development in the Rosslyn-Ballston, Columbia Pike, Pentagon City, Shirlington, and Jefferson Davis corridors;
- Continue to control runoff quality and quantity from development through the Chesapeake Bay, Erosion and Sediment Control, and Storm Water Detention Ordinances;
- Encourage water quality BMPs, in addition to stormwater detention, during the site plan review process;
- Outside the Rosslyn-Ballston, Columbia Pike, Pentagon City, Shirlington, and Jefferson Davis corridors, disconnect impervious cover from new development (and existing development) as much as possible to maintain or even reduce current levels of effective imperviousness in these areas;

- Outside the Rosslyn-Ballston, Columbia Pike, Pentagon City, Shirlington, and Jefferson Davis corridors, protect and, where possible, expand (through acquisition or conservation easements) stream valley parks such as Lubber Run, Bluemont, Glencarlyn, and Bon Air as well as land for stormwater retrofits;
- Ensure consistency of development in larger Four Mile Run watershed with USACOE flood control project while continuing to explore potential revisions to the flood control agreement; and
- Continue to support NVRC 's optical brightener outfall monitoring program in the Four Mile Run watershed to supplement the dry weather, illicit discharge inspection program required under the County's MS4 permit.

Subwatershed	Vacant, developable land	Predicted use for vacant land	Estimated built-out imperviousness
Colonial Village/Rocky Run	7.3%	8% low density 21% medium density 3% high density 70% commercial	51.3% (3.3% increase)
Doctors Branch	2.2%	52% low density 10% medium density 38% commercial	34.8% (0.8% increase)
Lower Four Mile Run	6.8%	25% low density 0.4% medium density 74% commercial	48.2% (3.2% increase)
Lower Long Branch	3%	50% low density 25% medium density 0.5% high density 24% commercial	38% (1% increase)
Lubber Run	4.4%	47% low density 2% medium density 2% high density 50% commercial	38.9% (1.9% increase)
Middle Four Mile Run	2.5%	45% low density 10% medium density 45% commercial	38% (1% increase)
Spout Run	3.9%	44% low density 7% medium density 48% commercial	40.4% (1.4% increase)
Upper Four Mile Run	1.7%	79% low density 11% medium density 10% commercial	25.4% (0.4% increase)

Table 11. Vacant land and estimated built-out impervious cover in ● subwatersheds.

2.6.2 Stormwater BMPs, BMP retrofits, and maintenance

Although identifying funds and/or available land to install new BMPs will be a challenging task, Arlington County's MS4 permit provides the legal obligation and authority to control runoff from existing development. Specifically, the County's MS4 permit states:

The permittee shall develop, implement, and, where appropriate, modify a comprehensive Storm Water Management Program...., including pollution prevention measures, management or removal techniques, storm water monitoring, use of legal authority, and other appropriate means to control the quality and quantity of stormwater discharged from the municipal separate storm sewer system [MS4]. The Storm Water Management Program shall....reduce the discharge of pollutants from the [MS4] to the maximum extent practicable (Commonwealth of Virginia, 1997).

The 'maximum extent practicable' requirement is not explicitly defined in the permit, but the permit does specify four tools to achieve this level of water resource management:

- 1) Implementing structural and source control measures to reduce pollutants discharged to the MS4 in stormwater runoff from commercial and residential areas;
- 2) Detecting and eliminating illicit discharges and/or improper disposal into the MS4;
- 3) Monitoring and controlling pollutants in storm water discharges from municipal landfills, hazardous waste treatment, storage, and disposal facilities, and certain industrial facilities; and
- 4) Implementing and maintaining structural and nonstructural measures to reduce pollutants in stormwater runoff from construction sites.

It is the first item, existing commercial and residential development, that presents the greatest challenge to the County. The County conducts annual dry weather inspections of major MS4 outfalls to implement item two of this list. Only a small number of facilities identified in item three exist within the County, and these are covered under existing permits.

The fourth item is mostly covered by the County's Erosion and Sediment Control Ordinance. However, the County should increase the frequency of construction site inspection and enforcement under this ordinance. To that end, DPW hired an additional Erosion and Sediment Control inspector in early 2000.

In Arlington County, implementation of the first item has been limited for existing or new development/redevelopment. Despite the difficulty of retrofitting existing residential and commercial development in an urban jurisdiction like Arlington because of limited funds and space for BMPs, inattention to stormwater runoff from existing development could result in enforcement actions by the State of Virginia under the NDPES stormwater program. Inaction could also subject the County or the State of Virginia to the possibility of citizen suits under the Clean Water Act. This is a real concern—environmental advocacy groups have won several successful suits recently to force EPA and the states to implement the TMDL provisions of the Clean Water Act, in Virginia and throughout the nation.

TMDL regulations will also directly affect Four Mile Run, and therefore much of the County, underscoring the need for an effective stormwater management program to address both runoff quality and quantity.

2.6.2.1 County-wide

This plan recommends the following BMP implementation strategy for the County, listed in an 'upstream-downstream' treatment hierarchy (items 2, 3, and 4 address runoff quality and quantity):

- 1) **Source control:** Identify funding to enable DES to purchase or lease at least one high-efficiency dry vacuum street sweeper and either an additional regenerative air sweeper or another dry vacuum sweeper; increase the frequency of sweeping in residential and commercial areas. These actions will remove sediment and associated pollutants at the source (paved areas) and will do so more frequently and more effectively than current street sweeping practices.

'On the street' performance data for relatively new high-efficiency dry vacuum sweepers, including analyses of optimal sweeping frequencies, are still limited²⁰. Early work by Sutherland (1995) estimates that the use of dry vacuum sweepers once per year could reduce annual sediment washoff by 20 percent, four times per year by 28 percent, and weekly by 80 percent. Regenerative air sweepers achieve an estimated 8 percent reduction in annual sediment washoff through annual sweeping, a 10 percent reduction through sweeping four times per year, and a 20 percent reduction through weekly sweeping. These preliminary estimates suggest sweeping using either technology should occur at least four times per year, but probably more frequently to obtain the best results. This would require a substantial increase in the County's street sweeping program.

More data are needed to determine optimal frequencies, and it is beyond the scope of this plan to recommend a specific combination of sweeping frequency and sweeper technology. However, recent peer reviewed articles have established dry vacuum sweepers as the Best Available Technology (BAT) sweepers for achieving water quality benefits. *Moreover, high efficiency sweepers may represent the best method of restoring water quality in older urban watersheds such as those in Arlington County where land, and BMP retrofit opportunities, are limited (NVRC, 1998).*

- 2) **Treatment upgradient of storm sewers and streams:** Complete an inventory of existing water quantity and quality BMPs and identify potential retrofits to improve detention capacity and pollutant removal efficiency. The inventory should explore site-level and small drainage area BMPs such as sand filters²¹, bioretention²², and check dams²³ for residential sites, including cul-de-sacs, and large public, office, and commercial sites, especially parking lots. These BMPs are designed for land-constrained urban areas and are relatively inexpensive to install and maintain. The inventory should also consider vegetated roofs and onsite detention/retention ponds for large sites and buildings where appropriate. Resources for implementing these BMPs include Coffman (2000), NVRC (1997),

²⁰ Ongoing work by the Wisconsin Department of Natural Resources is attempting to verify the benefits of dry vacuum sweepers on a six-lane freeway in downtown Milwaukee. The study will compare the water quality of stormwater runoff from freeway that is swept to an adjacent portion of freeway that is not swept. The test will be conducted in both the summer and winter seasons, and water quality samples will be analyzed for several different types of pollutants. The study should be completed by summer 2000 (Bannerman, 1999). In addition, the Lake Barcroft Watershed Improvement District conducted a one-week demonstration of high-efficiency dry vacuum street sweeping in 1998. The high-efficiency sweeper collected twice as much fine sediment as a conventional sweeper (Lubold, 1998).

²¹ A sand filter diverts and filters runoff through a self-contained sand bed before discharging the runoff to a stream channel (Claytor and Schueler, 1996).

²² Bioretention uses landscaping and soil to treat stormwater by collecting it in shallow depressions and filtering it through the planted soil media (Claytor and Schueler, 1996).

²³ A 'check dam' attenuates storm flow and, in urban areas, typically consists of a railroad tie perpendicular to the direction of flow with rip-rap placed on the downstream end of the check dam to prevent erosion. Check dams can be used in vegetated swales to slow stormwater runoff velocities (NVPDC, 1997).

Claytor and Schueler (1996), Northern Virginia Soil and Water Conservation District (NVSWCD) (1994), and the City of Alexandria (1992).

- 3) **Treatment between surface drainage/storm sewer interface and storm sewer/stream interface:** The County should install in-line devices wherever appropriate to filter stormwater at strategic locations within the storm sewer system (especially high risk or chronic spill areas) that maximize filter capacity and cost-effectiveness, using RSAT water quality scores and/or land uses a screening tool.²⁴
- 4) **Treatment downstream of storm sewer/stream interface:** Continue to explore the recommendations of a 1993 report by the Northern Virginia Planning District Commission (NVRC) that identified and investigated the feasibility of 24 potential regional BMPs in the Four Mile Run watershed—the report concludes that, despite the level of urban development in the watershed, opportunities for regional BMPs do exist (NVRC, 1993). The County should assess the feasibility of regional BMPs in other County subwatersheds.

It must be stressed that without regular inspections and maintenance, structural BMP strategies will not be successful. Therefore, it is imperative that the County identify funding and/or procedures not only to retrofit or install BMPs but also to inspect and maintain them. This issue will be discussed in the 'Implementation plan' section. For privately-owned BMPs, the City of Alexandria has developed a maintenance and monitoring agreement with property owners that could be adopted in Arlington (City of Alexandria, 1992).

By reducing pollutant loads to County streams, beginning with source reduction through street sweeping, this approach will help ensure compliance with the County's MS4 permit. Overall, because of the limited open space in the County, Arlington County should explore these BMP retrofit opportunities wherever feasible, similar to the City of Alexandria's 'Targets of Opportunity' policy described above. In particular, sewersheds²⁵ with outfalls 36 inches in diameter or greater²⁶ and sewersheds that contain RSAT stations with water quality scores less than three should receive priority attention (the majority of water quality scores at all RSAT stations, 62 percent, totaled between three and four; only 14 percent of water quality scores at all RSAT stations were greater than four).

2.6.2.2 Subwatershed strategies

The three sections below describe subwatershed-specific applications of the hierarchy presented above.

2.6.2.2.1 Least impacted subwatersheds (○) and More impacted subwatersheds (●)

BMP implementation strategies for Gulf Branch, Donaldson Run, Little Pimmit Run, Upper Long Branch, and Windy Run are similar, with an increased focus on channel protection for Windy Run and Little Pimmit Run because of higher levels of impervious cover.

²⁴ The RSAT water quality parameter consists of an evaluation of water clarity/visibility (poor, <0.5', fair, 0.5'-1.5'; good, 1.5'-3.0', and excellent, >3.0'), odor (poor, strong organic odor; fair, moderate organic odor; good, slight organic odor; excellent, no odor), and substrate fouling, an observation of the extent of algal and bacterial growth on stream bed material (poor, >50%; fair, 21-50%; good, 11-20%; excellent, 0-10%).

²⁵ The term 'sewershed' is used here because most of Arlington County's drainage network is comprised of storm sewers. A sewershed is simply an area in which all surface water drainage exits a specific storm sewer outfall to a stream channel.

²⁶ Discharges from outfalls less than this diameter should have fewer adverse physical effects on stream channels. In addition, the County's MS4 permit defines a major outfall using this 36 inch threshold.

- 1) **Source control:** Implement regenerative air and/or dry vacuum street sweeping in residential areas at least four times per year and weekly in commercial/industrial areas; encourage property owners to disconnect roof drains from the storm sewer system where possible.
- 2) **Treatment upgradient of storm sewers and streams:** Begin evaluation of small-scale BMPs by focusing on:
 - a) Sewersheds upgradient of RSAT stations with water quality scores less than three (poor) (Figure 22);
 - b) Sewersheds that contain land uses other than low density or parkland; and
 - c) Cul-de-sacs and parking lots.
- 3) **Treatment between surface drainage/storm sewer interface and storm sewer/stream interface:** Determine optimal locations to install in-line devices to filter stormwater, focusing on:
 - a) Sewersheds with outfalls equal to or greater than 36 inches in diameter (Figure 22);
 - b) Sewersheds upgradient of RSAT stations with water quality scores less than three (poor) (Figure 22); and
 - c) Sewersheds that contain land uses other than low density residential or parkland.
- 4) **Treatment downstream of storm sewer/stream interface:** Perform feasibility studies in these subwatersheds to identify potential locations for BMPs; preliminary candidate sites include Arlington Country Club, Gulf Branch Nature Center, Rock Spring Park, and Woodmont Center; target BMPs that emphasize channel protection (by releasing water at a 1-year recurrence interval, for example) as well as pollutant reductions.

2.6.2.2.2 *Most impacted subwatersheds (●)*

BMP implementation approaches in the Lower Long Branch, Doctors Branch, Spout Run, Lubber Run, Colonial Village/Rocky Run, Upper Four Mile Run, Middle Four Mile Run, and Lower Four Mile Run subwatersheds are similar to those for the 'Least impacted' and 'More impacted' subwatersheds, except for a focus on a) sewersheds that contain RSAT stations with water quality scores less than two (rather than three) in recognition of potentially higher pollutant loadings in these subwatersheds, and b) source control efforts and BMPs that reduce bacterial pollution, since all of these subwatersheds (except for Spout Run and Colonial Village/Rocky Run) are within the larger Four Mile Run watershed—a DEQ-identified impaired stream for fecal coliform bacteria that will be subject to the TMDL program.

- 1) **Source control:** Implement regenerative air and/or dry vacuum street sweeping in residential areas at least four times per year and weekly in commercial/industrial areas; disconnect roof drains from storm sewer system where possible; develop bacterial loading reduction strategies from results of NVRC bacteria source identification study (e.g., dog parks; increased 'pooper scooper' stations, wildlife control, increased I&I inspection, etc.);
- 2) **Treatment upgradient of storm sewers and streams:** Begin evaluation of small-scale BMPs by focusing on:
 - a) Sewersheds with outfalls equal to or greater than 36 inches in diameter (Figure 23) (a larger diameter threshold may be more practical for these subwatersheds);
 - b) Sewersheds upgradient of RSAT stations with water quality scores less than two (very poor) (Figure 23);
 - c) Sewersheds that contain land uses other than low density, medium density, or parkland; and
 - d) Parking lots.
- 3) **Treatment between surface drainage/storm sewer interface and storm sewer/stream interface:** Determine optimal locations to install in-line devices to filter stormwater, focusing on:
 - a) Sewersheds upgradient of RSAT stations with water quality scores less than two (very poor) (Figure 23); and
 - b) Sewersheds that contain land uses other than low density, medium density, or parkland, especially sewersheds with known 'hotspots', such as industrial areas (e.g., Trades Center and other facilities in Shirlington).

Figure 22. BMP retrofit priority locations: Gulf Branch, Donaldson Run, Windy Run, Little Pimmit Run, and Upper Long Branch.

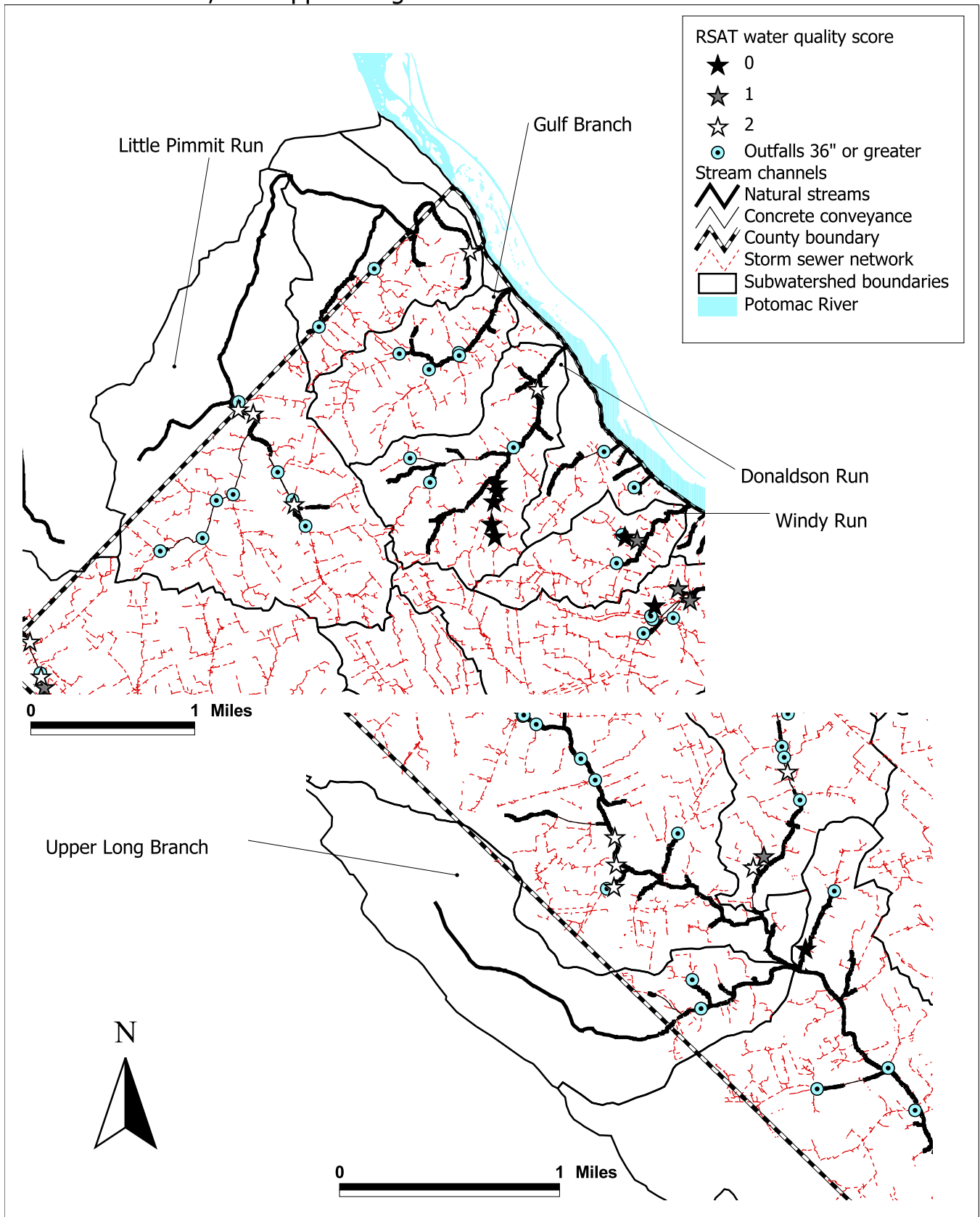
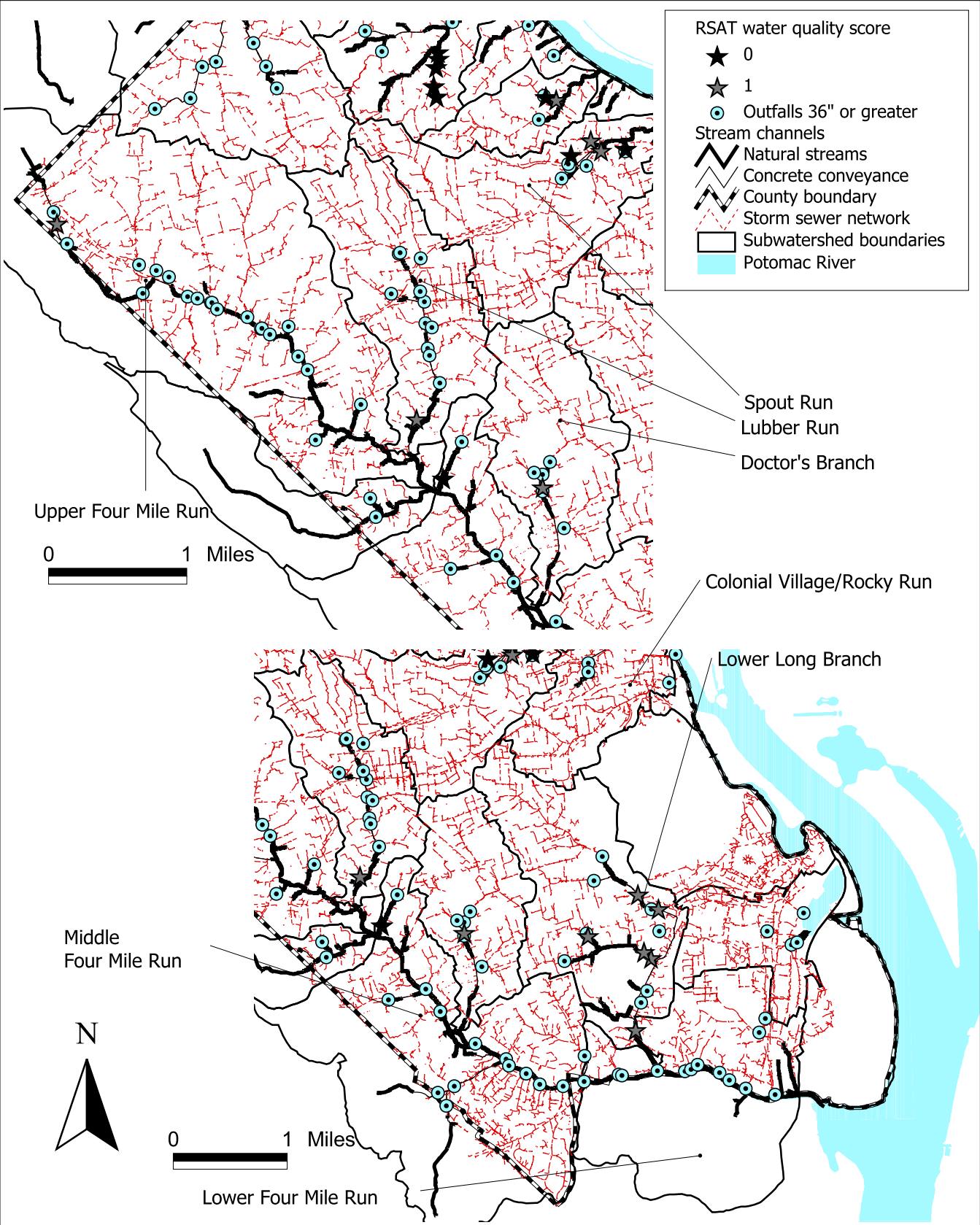


Figure 23. BMP retrofit priority locations: Lower Long Branch, Doctors Branch, Spout Run, Lubber Run, Colonial Village/Rocky Run, Upper Four Mile Run, Middle Four Mile Run, and Lower Four Mile Run.



- 4) **Treatment downstream of storm sewer/stream interface:** Follow-up on NVRC 's BMP feasibility analysis for the Four Mile Run watershed and target BMPs that reduce bacterial pollution as well as flooding, consistent with Four Mile Run flood control project; evaluate effectiveness of Ballston Beaver Pond in Lubber Run; perform feasibility studies in Spout Run and Colonial Village/Rocky Run to identify potential locations for BMPs.

2.6.3 Stormwater infrastructure

Of the five components identified to implement this watershed management plan, Arlington County's storm sewer and sanitary network maintenance program may be the most systematic, as described above in Section 2.2, 'Existing County water resource and runoff management practices.'

However, DPW's Water, Sewer, and Streets division does not currently have adequate staff to monitor this network continually, and the stream inventory revealed a number of locations in the County with utility crossing and storm sewer outfall problems, as shown in Figure 24 and Figure 25. At several locations in the County, sanitary sewer lines buried under stream beds are now exposed as a result of stream channel erosion. In addition, at a number of locations in the County, scour pools that have developed from high velocity flow from a storm sewer outfall have undermined the aprons, riprap, wingwalls, or headwalls that support the outfall. A collapsed outfall can lead to pipe joint separations and severe local bank erosion. Figure 24 also shows locations where stream inventory staff observed sewage odors as a result of sanitary sewer vents as well as locations where gray water or fungal growth indicated a potential sanitary sewer leak. Actual sanitary sewer line breaks observed during the inventory were reported to DPW and fixed (ESA, 1999).

In conjunction with the implementation of a watershed tracking system (described in Section 2.7), County staff that observe stormwater infrastructure problems in the field should report their observations to DPW to supplement DPW's regular inspection and maintenance program.

2.6.4 Stream and buffer management, restoration, and monitoring

2.6.4.1 Management and restoration

The stream inventory and RSAT data provide comprehensive information to prioritize and coordinate stream and buffer management in the County. The County can use the scores for specific RSAT parameters as tools to implement a County-wide stream and buffer management strategy that:

- 1) Prioritizes and stabilizes failing channels to an equilibrium state (channel stability, channel scouring/sediment deposition), including exploring stream restoration opportunities for stream reaches where an *artificially hardened* channel is failing;
- 2) Restores instream substrate and habitat (physical in-stream habitat);
- 3) Re-establishes riparian cover (riparian habitat), consistent with the Chesapeake Bay Program goal of reforesting stream buffers in the 64,000 square mile bay watershed.;
- 4) Improves stream aesthetics (aesthetics); and
- 5) Restores entire stream reaches (total RSAT station score).

A practical starting point to prioritize stream and buffer management/restoration could be to focus on those stream reaches where RSAT station score, RSAT channel stability score, *and* at least one of the other RSAT parameters (channel scouring/sediment deposition, physical in-stream habitat, riparian habitat, and aesthetics) are below the 'good' or 'fair' range, depending upon the management goals for a given subwatershed (i.e., least impacted, more impacted, most impacted). This approach emphasizes the importance of channel stability to stream health while ensuring that the stream reaches in the poorest condition are addressed first.

Figure 24. Utility crossing problems.

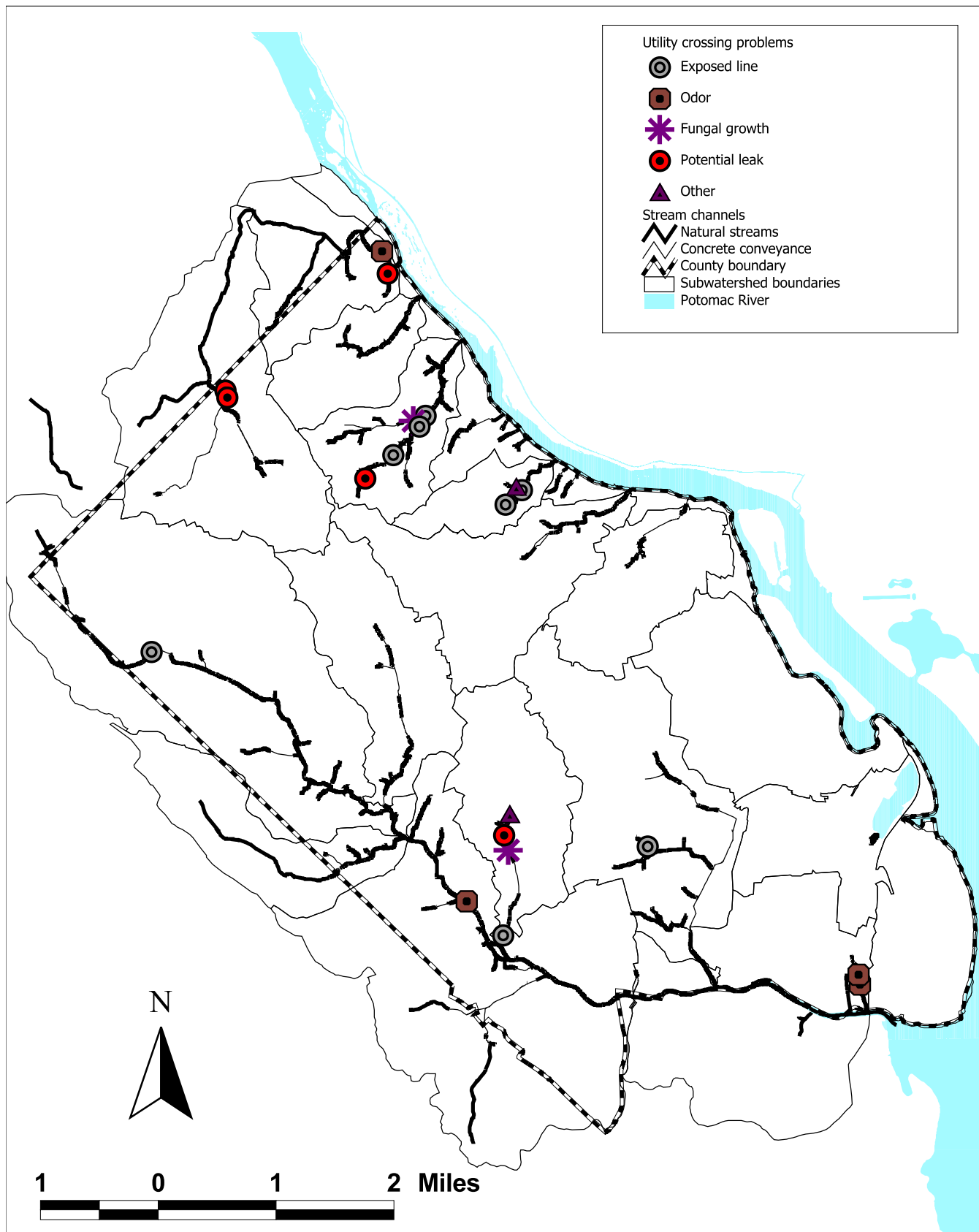
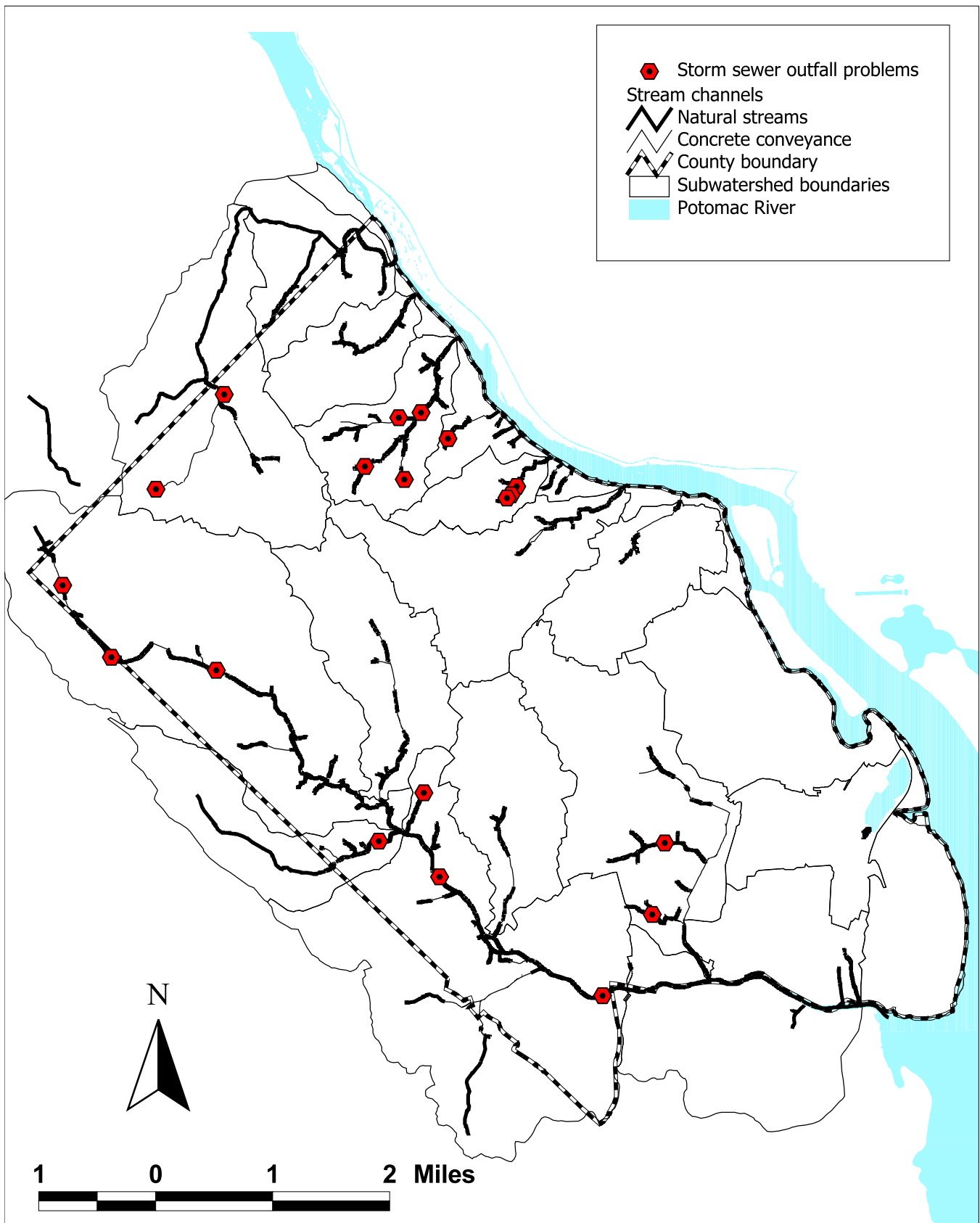


Figure 25. Storm sewer outfall problems.



An additional component to this approach could be to explore opportunities to 'daylight' streams that are currently in underground pipes by recreating stream channels at the surface.. This process would help to restore the County's stream network to its pre-development conditions. The feasibility of 'daylighting' is limited on a County-wide scale, but there may be a number of opportunities to investigate this stream restoration approach.

In the Four Mile Run watershed, PRCR is currently evaluating opportunities for buffer expansion in the stream valley. The majority of areas PRCR has identified for potential expansion are most suitable as 'no mow' areas, with a few locations where reforestation may be possible.

Field observations at each of the 236 stations surveyed for the inventory also provide a more specific 'to do' list for removing stream obstructions, expanding riparian buffers, removing invasive species, and addressing channel erosion. In an already eroded urban stream, obstructions such as fallen trees that span a stream channel can exacerbate bank erosion and collapse. Most of the stream obstructions observed during the inventory were small accumulations of logs and/or other debris which occasionally spanned an entire stream width. Most of the obstructions do not yet present a threat to stream banks but are likely to with further accumulation of debris (ESA, 1999).

Riparian vegetation is widely recognized for its benefits to near-stream and in-stream ecology. The stream inventory identifies a number of locations where riparian vegetation could be planted or expanded to increase riparian buffer widths. The inventory also noted locations where the County should control invasive species such as kudzu and porcelainberry, especially along the tops of stream banks and within stream channels (ESA, 1999).

In addition, the stream inventory noted actively eroding streams with significant channel downcutting, bank undercutting, bank failure, and gully erosion. These represent priority areas for stream restoration (ESA, 1999).

2.6.4.1.1 Subwatershed strategies

2.6.4.1.1.1 Least impacted subwatersheds (O)

In Gulf Branch and Donaldson Run:

- Investigate acquiring land or conservation easements for vacant parcels such as those adjacent to Glebe Recreation Area in the headwaters of a Gulf Branch tributary;
- Improve and coordinate management of publicly-owned streams and buffers (Gulf Branch: Gulf Branch Nature Center, Glebe Recreation Area, Madison Center; Donaldson Run: Potomac Overlook Regional Park, Taylor Park, and Taylor Elementary; and
- Evaluate priority stream reaches for improvement; focus on stream reaches with total RSAT station scores less than 30, channel stability scores less than six, and one of the following: channel scouring/sediment deposition scores less than five, instream substrate/habitat scores less than five, riparian habitat scores less than four, stream aesthetics scores less than four. (Figure 26).

Specific stream reach action items (Figure 28, Figure 29, and Figure 30):

- Expand riparian buffers at two locations along Gulf Branch mainstem and five locations in Donaldson Run within the Washington Golf/Country Club;
- Remove stream obstruction in Donaldson Run; and
- Address active channel erosion at two locations in Gulf Branch and five locations in Donaldson Run (and restore degraded Taylor Park tributary, with the goal of achieving a 'good' RSAT score).

2.6.4.1.1.2 *More impacted subwatersheds* (●)

In Little Pimmit Run, Upper Long Branch, and Windy Run:

- Investigate acquiring land or conservation easements for vacant parcels adjacent to stream channels in both subwatersheds;
- Improve and coordinate management of publicly-owned streams and buffers (Windy Run: Windy Run Park; Little Pimmit Run: Rock Spring Park, Upper Pimmit Run park); and
- Avoid or re-engineer hardened channels (e.g., bioengineering as part of Little Pimmit Run flood control project); and
- Evaluate priority stream reaches for improvement; focus on stream reaches with total RSAT station scores less than 30, channel stability scores less than six, and one of the following: channel scouring/sediment deposition scores less than five, instream substrate/habitat scores less than five, riparian habitat scores less than four, stream aesthetics scores less than four. (Figure 26).

Specific stream reach action items (Figure 28, Figure 29, and Figure 30):

- Re-evaluate potential locations to expand riparian buffers (none found during stream inventory);
- Remove stream obstruction in Little Pimmit Run; and
- Address active channel erosion at one location in Little Pimmit Run and three locations in Windy Run.

2.6.4.1.1.3 *Most impacted subwatersheds* (●)

In Lower Long Branch, Doctors Branch, Spout Run, Lubber Run, Colonial Village/Rocky Run, Upper Four Mile Run, Middle Four Mile Run, and Lower Four Mile Run:

- Investigate acquiring land or conservation easements for vacant parcels adjacent to stream channels in both subwatersheds, with focus on flood control;
- Improve and coordinate management of publicly-owned streams and buffers; and
- Evaluate priority stream reaches for improvement; focus on stream reaches with total RSAT station scores less than 15, channel stability scores less than three, and one of the following: channel scouring/sediment deposition scores less than three, instream substrate/habitat scores less than three, riparian habitat scores less than two, stream aesthetics scores less than two. (Figure 27).

Specific stream reach action items (Figure 28, Figure 29, and Figure 30):

- Expand riparian buffers at three locations in Upper Long Branch, 11 locations in Lower Long Branch, one location in Spout Run, four locations in Lubber Run, two locations in Colonial Village/Rocky Run, 30 locations in Upper Four Mile Run (control invasives at 2 locations), eight locations in Middle Four Mile Run, three locations in Lower Four Mile Run;
- Remove stream obstructions at five locations in Lower Long Branch, two locations in Doctor's Branch, one location in Upper Four Mile Run, four locations in Middle Four Mile Run, one location in Lower Four Mile Run; and
- Address active channel erosion at one location in Upper Long Branch, five locations in Lower Long Branch, three locations in Lubber Run, one location in Colonial Village/Rocky Run, 16 locations in Upper Four Mile Run, and three locations in Middle Four Mile Run.

Figure 26. Priority stream reaches: Gulf Branch, Donaldson Run, Windy Run, Little Pimmit Run, and Upper Long Branch.

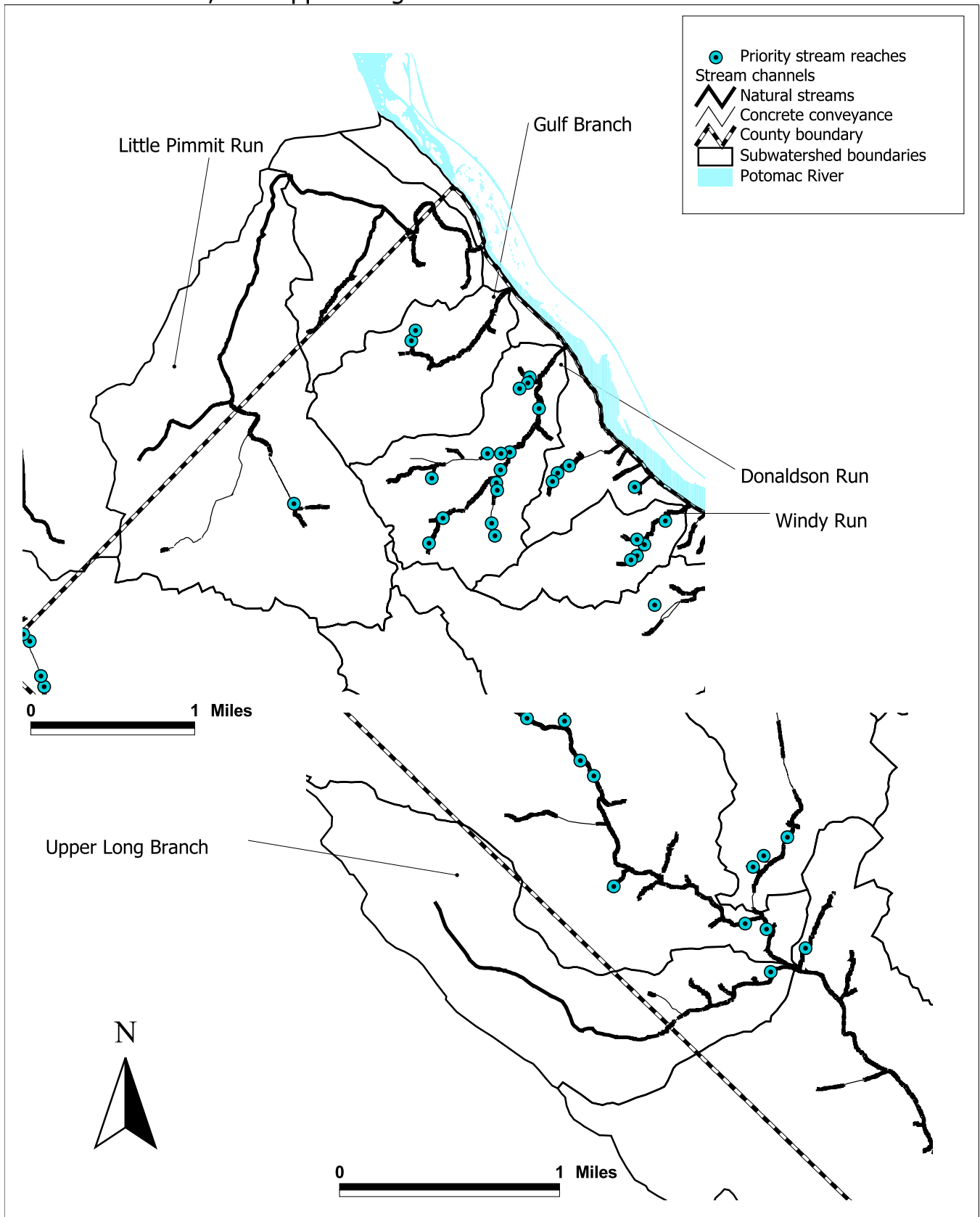


Figure 27. Priority stream reaches: Lower Long Branch, Doctors Branch, Spout Run, Lubber Run, Colonial Village/Rocky Run, Upper Four Mile Run, Middle Four Mile Run, and Lower Four Mile Run.

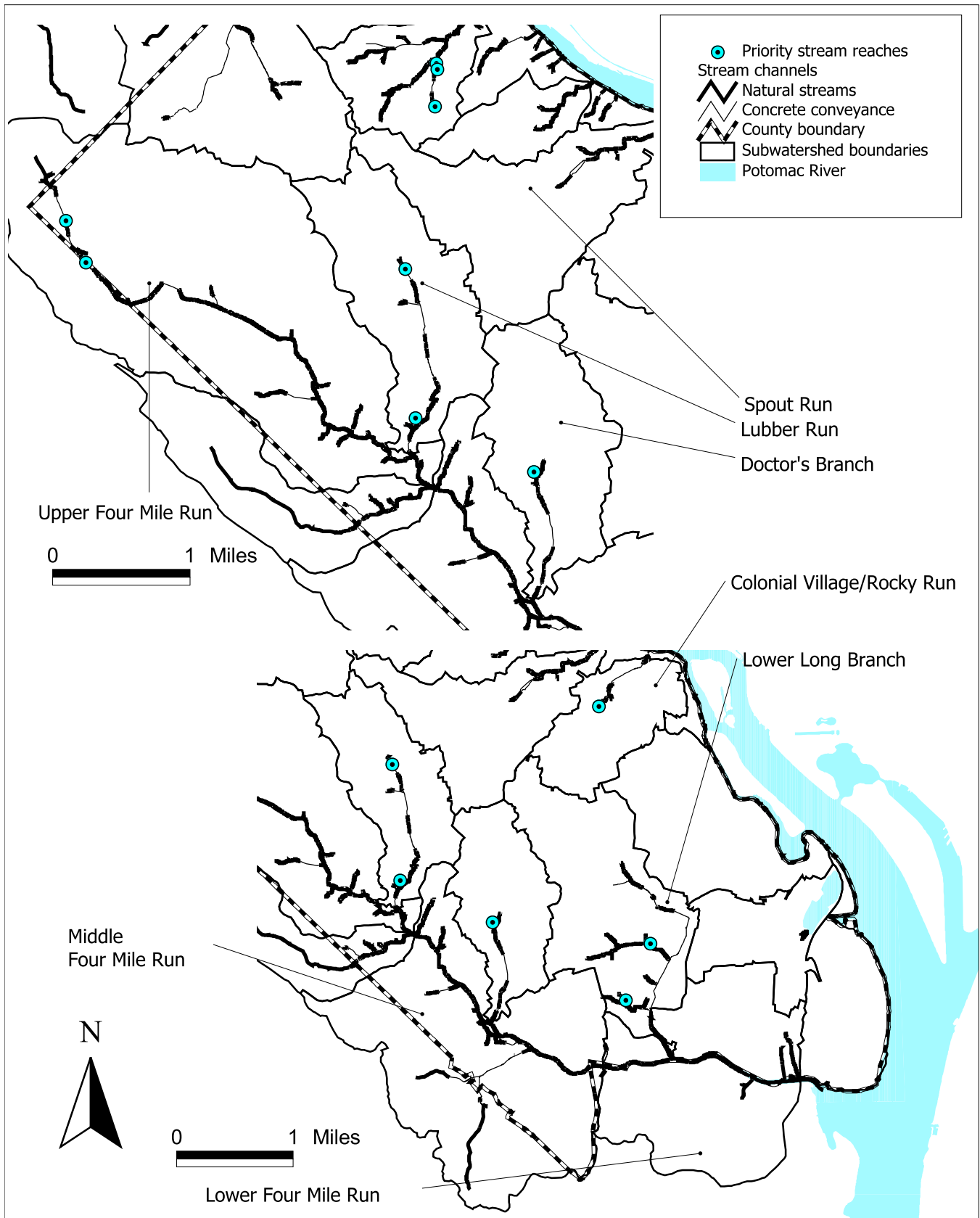


Figure 28. Stream obstructions.

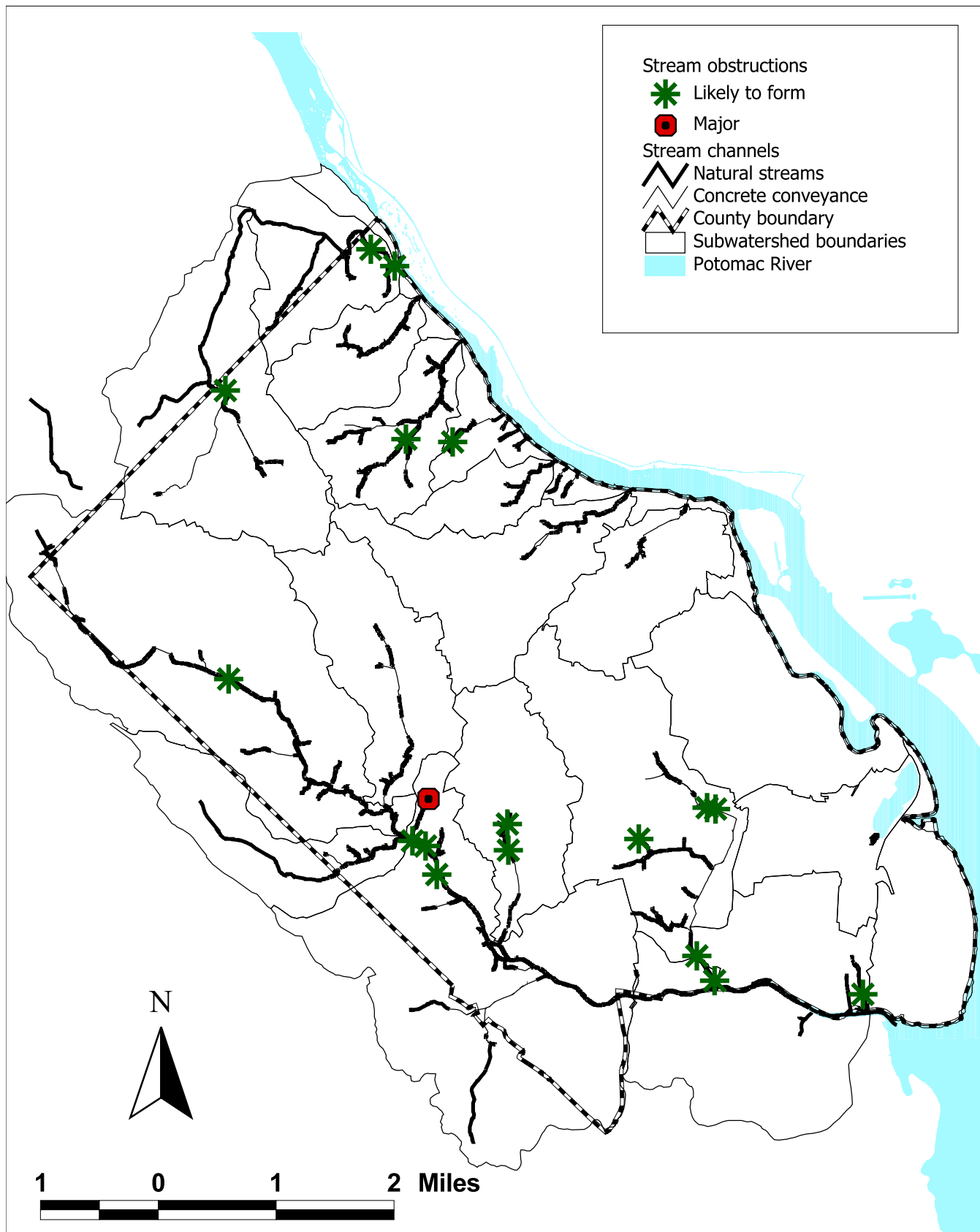


Figure 29. Riparian buffer recommendations.

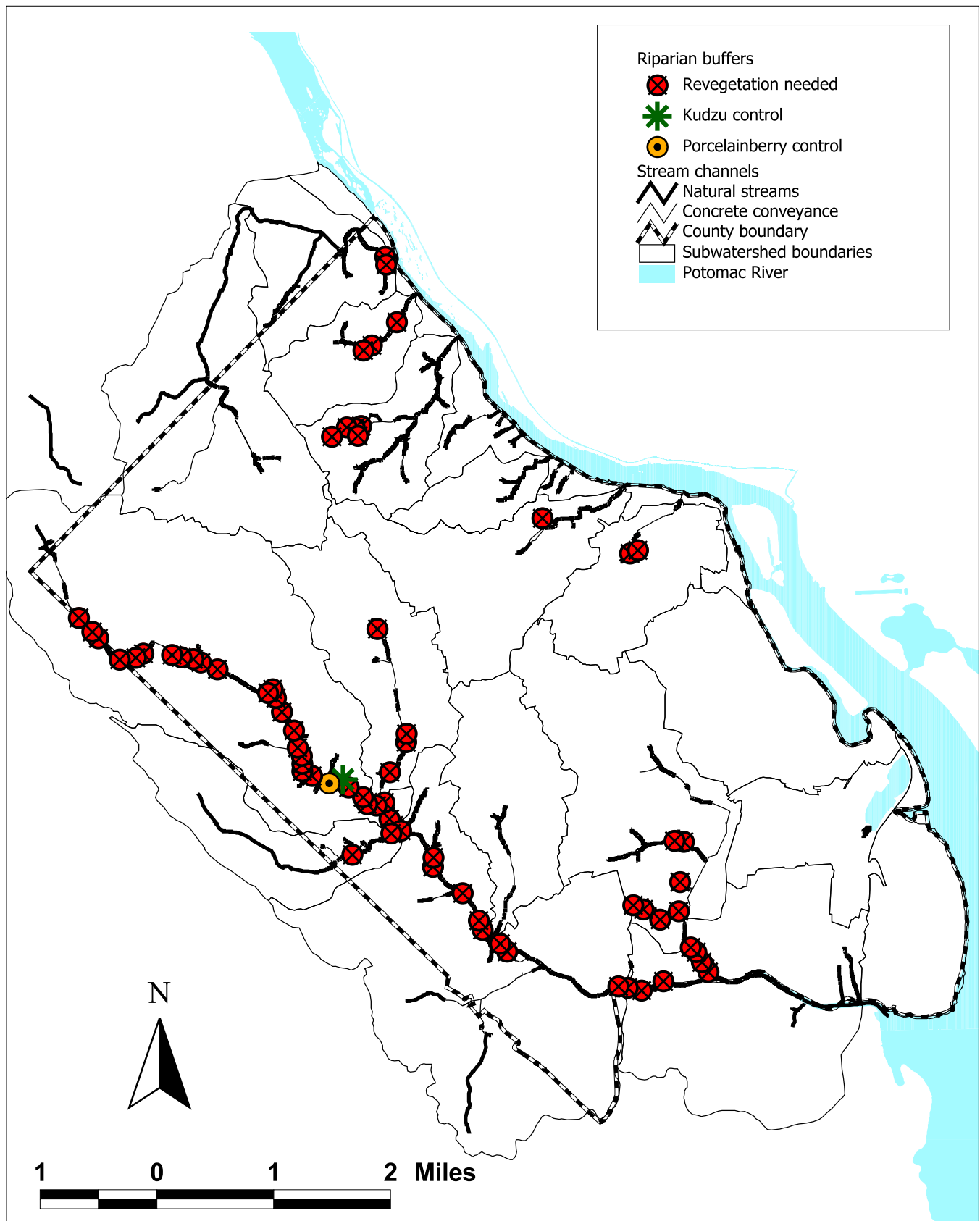
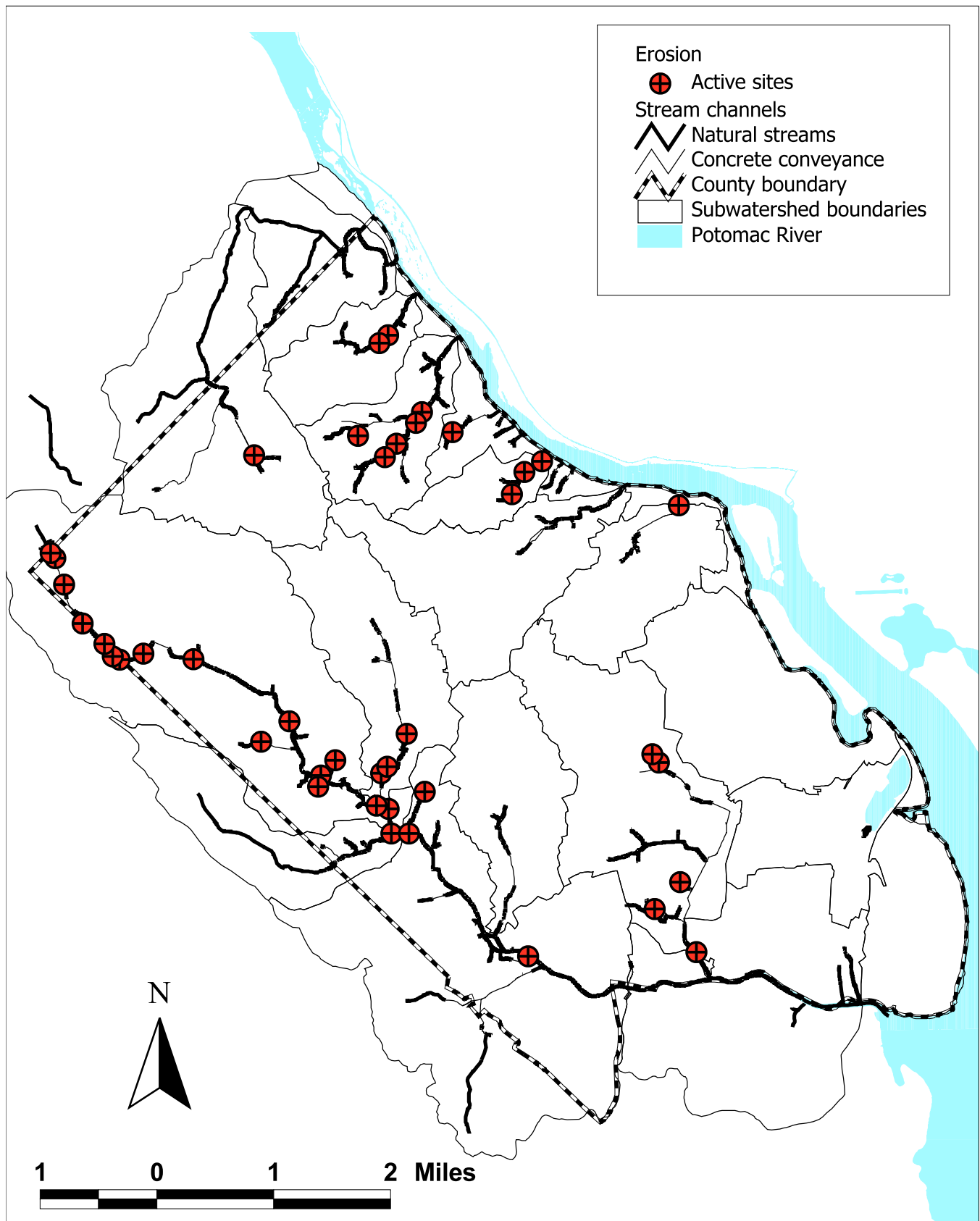


Figure 30. Channel or streambank erosion.



2.6.4.2 Monitoring

During the stream inventory, ESA and Arlington County established 15 'long-term' monitoring stations in 10 subwatersheds. At these stations, the County measured channel cross sections, installed bank pins to measure stream channel erosion and downcutting, and performed a screening-level macroinvertebrate survey, with specimen identification to the family level.

These 15 stations will serve as focal points for future in-stream monitoring. EPO has already had discussions with Arlingtonians for a Clean Environment (ACE), Audubon Naturalist Society (ANS), Potomac Conservancy, and Friends of Four Mile Run to discuss coordinated stream monitoring in Arlington County at these stations. Volunteer citizen monitors will be critical for staffing this effort, and these groups have large memberships from which to draw. Ideally, a citizen watershed coordinator or team would be appointed for each County subwatershed to help oversee and coordinate monitoring activities.

Monitoring activities at the 15 stations will consist of:

- Biological monitoring for macroinvertebrates, with identification to the genus level, using standard methods such as EPA's Rapid Bioassessment Protocol for Use in Streams and Wadeable Rivers (EPA, 1999a);
- Chemical monitoring during baseflow and stormflow conditions; and
- Physical monitoring of streamflow and channel characteristics.

The objectives of such monitoring include:

- Refining baseline subwatershed conditions that account for seasonal and meteorological variation;
- Measuring changes in stream hydrology and chemistry, stream channel morphology, and stream biology over time to assess progress towards the management goals for the three categories of subwatersheds—including the effects of BMPs and stream restoration, as well as development projects, on stream health;
- Determining the extent, magnitude, and variability of fecal coliform pollution in the Four Mile Run watershed (building on the NVRC bacterial DNA study).

Clearly, these monitoring activities cannot be conducted simultaneously at all 15 stations because of limited staff and funds. With input from ACE, ANS, NVRC, adjacent jurisdictions with monitoring programs such as Fairfax County, and others, EPO will develop a monitoring plan and a schedule for implementation. In the meantime, EPO and ANS are planning a macroinvertebrate sampling event at one or two of the 15 monitoring stations to assess citizen interest and to evaluate results obtained with a more rigorous and detailed sampling methodology with the preliminary macroinvertebrate data collected during the stream inventory.

EPO already has stream monitoring equipment that includes a portable automatic sampler, a portable colorimeter for chemical tests, a flow meter, a stream probe that measures parameters such as dissolved oxygen, conductivity, pH, and temperature, and macroinvertebrate sampling nets. The County's Source Control Fund can provide funding for additional equipment, such as water level monitors, needed for a County-wide monitoring program.

The County will also continue to monitor four storm sewer outfalls as required by its MS4 Permit. As the stormwater dataset increases in size and the magnitude and seasonal characteristics of pollutant loadings

from the four outfalls can be determined with more confidence, the County can use the data to target stormwater management strategies for the four land use types drained by the four outfalls.

2.6.5 Pollution prevention and watershed education

Pollution prevention and watershed education programs can be categorized as follows:

- Programs targeting citizens;
- Programs targeting public and private entities, such as County facilities, private businesses, and developers; and
- Programs targeting County employees responsible for stream and buffer management.

As described in the 'Existing County water resource and runoff management practices' section of this report, Arlington County, along with NVRC, ACE, and Arlington VCE, implement a wide range of programs targeting citizens. These activities could be improved by better communication among the responsible agencies (e.g., a committee could be established to exchange ideas and coordinate programs), but, ultimately, these programs are well-run and moderately effective.

Arlington County should also consider installing signs in high-visibility areas that mark the drainage boundaries for County subwatersheds. These signs, in conjunction with 'watershed walks', would be valuable educational tools to raise watershed awareness and reinforce the 'know your watershed address' theme. The County should also make use of television and radio in its public awareness efforts because of their proven ability to reach a much wider audience. Targeted mailings to residents in specific subwatersheds or to riparian property owners should also be used.

The County has not been very active in the other two categories of watershed education described at the beginning of this section. Given the 'ultra-urban' nature of Arlington County, programs that target the public and private office, commercial, and industrial sites in the County are also critical to the success of a watershed management program—and compliance with the 'maximum extent practicable' provisions of the County's MS4 permit. The GIS-based land use analysis presented in this plan can be used as a tool to target these facilities.

To start this process, Arlington County should develop a brochure for site owners and occupants that describes: a) Arlington County's legal responsibility to control stormwater runoff and stream pollution; b) how buildings, parking lots, and typical site operations contribute to increased stormwater runoff and stream pollution; and, c) what can be done to reduce these impacts (e.g., bioretention areas to treat parking lot runoff, rooftop gardens, covered waste piles, etc.). Used in conjunction with a program such as a stormwater utility (see 'Implementation plan' section), implementation of activities at a given site that reduce stormwater runoff and pollution could be encouraged by a reduced utility fee. In the absence of a stormwater utility, the County should investigate incentives to implement such programs (for commercial development, at least), including publicity on the County website, or, possibly, some form of tax relief.

For new development/redevelopment, the Green Building Pilot Program, with an expanded stormwater management component, could serve as a mechanism to encourage site design that minimizes stormwater runoff. In fact, an in-line filter manufactured by Vortech, Inc., recently received U.S. Green Building Council (USGBC) certification to fulfill the 'surface water filtration credit' of the USGBC's Leadership in Energy and Environmental Design (LEED) green building rating system (Vortech, 2000). In addition, a County-wide stormwater management voluntary program could be created that would set targets for reducing runoff and pollution from different types of sites.

For residents, schools, and non-profit groups, the Source Control Fund could be used to support an annual small watershed grants program, with awards of \$10,000 to \$20,000 to fund stream restoration projects County-wide.

Internally, Arlington County's stream and buffer management practices have improved over the years—streambank stabilization projects in portions of Four Mile Run and Donaldson Run, for example, provide evidence of sound restoration practices. Yet, both the Planning and Design and Parks and Natural Resources divisions of PRCR have identified a need for better education for staff about stream and buffer maintenance. Similarly, DPW's Engineering division, which oversees streambank stabilization and improvement projects in the County, could benefit from stream restoration training to improve the effectiveness of the division's stream projects. Time is limited for members of these PRCR and DPW divisions to attend formal training classes to improve their management practices. However, a one- or two-day, on-site seminar would be a good place to start.

In addition, facilitated by the recent redesign of the County Internet site, EPO plans to expand the information provided on its own homepage to include much of the data presented in this Watershed Management Plan, including maps and photos, along with water-related educational information. EPO will start working on this effort with the County's contracted web designers during the summer of 2000.

2.7 Watershed Tracking System

Coordinated and systematic implementation of the actions identified in this Watershed Management Plan is critical to successful local water resource management in Arlington. A key component for such coordinated implementation—and therefore for effective watershed management—will be an information system (or systems) to track:

- 1) Development projects in the County, including size, impervious cover, and location, as well as implementation and enforcement data for the Stormwater Detention, Chesapeake Bay Preservation, and Erosion and Sediment Control ordinances;
- 2) Spills and illicit discharges;
- 3) Stormwater BMPs and BMP retrofits, including type, cost, inspection, and maintenance data;
- 4) Stormwater infrastructure projects, including I&I and sanitary sewer leak data; and
- 5) Stream and buffer projects, including restoration project costs, and physical, chemical, and biological stream monitoring data, and buffer reforestation data.

By consolidating the key measures of development, runoff management, and stream health, this information system will facilitate evaluation at the subwatershed level of the cumulative effects of individual development decisions in the County on streams and buffers. The system will also allow staff to assess the effectiveness of runoff management, stream restoration, and watershed education/pollution prevention strategies. Table 12 provides the major element and subelements of this system, organized according to the watershed management categories identified in this plan. The table also provides, where known, the data owner, the format of the data, and the frequency of update.

As indicated by Table 12, developing such a system will not be an easy task. Many data elements are not currently collected, and the data elements that are available are not all in a consistent format. Further, real time acquisition of some data may not be possible. However, the table also indicates that some data elements are already available and others will begin to be collected soon.

In particular, CPHD's Inspection Services Division maintains the 'Permits Plus' system, which tracks all building permits issued in the County. This extensive system includes parcel information such as location, size, and building square footage. DES and CPHD have had preliminary discussions about the

possibility of expanding the system to include information connected to a specific parcel—especially information related to the Stormwater Detention Ordinance, Chesapeake Bay Preservation Ordinance, and Erosion and Sediment Control Ordinance.

The next steps include meeting with data owners to refine data availability and format, working with CPHD's data systems specialist to determine the feasibility of expanding the Permits Plus system, and outlining the design for the other portions of the system. The goal is to develop procedures for data acquisition and entry and to construct a georeferenced database (or series of databases) that can be accessed by staff County-wide.

Watershed management category	Data element	Subelements (italics denote subelement not yet available)	Owner(s)	Format (italics denote planned format)	Frequency of update	Comments
Sources of stormwater runoff and dry weather pollution	Residential and non-residential development projects	Site location, parcel size, building footprint, %d	CPHD Inspection Services	Permits Plus system (Microsoft Access database)	Real time	
		Approved site plans				
		Under construction				
		Completed				
	ChesBay Ordinance	Site location, parcel size, building footprint, %d	DPW, DES EPO	Paper	As projects are proposed/completed	Permits Plus system contains site location, parcel size
		Exception requests				
		Waivers				
		On-site BMPs				
	Stormwater Detention Ordinance	Source Control Fund contribution	DPW	Paper	As projects are proposed/completed	NVRC has data through 1993 to run stormwater model for USACOE flood control project; DPW files contain data from 1994 to present; Permits Plus system contains site location, parcel size
		Site location, parcel size, building footprint, %d, cfs increase				
		Waivers				
Stormwater BMPs, BMP retrofits, and maintenance	Erosion and Sediment Control Ordinance	Locations of active building sites	DPW	Paper		The Virginia Department of Conservation and Recreation audits the County's E&S program every two years, with a report presented to the County Board; Permits Plus system contains locations of active building sites
		Area of disturbance				
		Inspections				
		Enforcement				
	Spills	Active/ongoing (volume, material, response)	ECC	Pollution response tracking system (planned)		
		Past (volume, material, response)				
		Sewer leaks				
		Location				
	Illicit discharges	Remediation	DPW WSS, EPO	Paper	As incidents occur	
		Complaints				
		Penalties				
		Location				
Stormwater infrastructure	Stormwater detention facilities	Type/capacity/cost	DPW, DES EPO, Schools	DPW spreadsheet	As projects are proposed/completed	DPW WSS conducting inventory of all facilities; DPW stores mylars for all private development projects, but schools keeps data separately.
		Location				
		Inspections/maintenance				
		Enforcement				
	ChesBay BMPs	Type/capacity/cost	DPW, DES EPO	Paper	As projects are proposed/completed	
		Location				
		Inspections/maintenance				
		Enforcement				
	Other BMPs (e.g., regional facilities, in-line systems)	Type/capacity/cost	DPW, DES EPO	Paper	As projects are proposed/completed	
		Location				
		Inspections/maintenance				
		Enforcement				
Stormwater infrastructure	Storm sewer rehabilitation	Inspection/maintenance	DPW WSS	Paper/some * dbf, GIS	As projects are proposed/completed	
		High infiltration areas				
		Resolution				
		Incidents/volume				
Sanitary sewer overflows and leaks		Resolution	DPW WSS, DES WPCD	Paper		WPCD must report sanitary sewer overflows to Virginia DEQ

Table 12. Data elements for Watershed Tracking System.

January 2001

Watershed management category	Data element	Subelements (<i>italics denote subelement not yet available</i>)	Owner(s)	Format (<i>italics denote planned format</i>)	Frequency of update	Comments
Stream and buffer management, restoration, and monitoring	Stream inventory	Station location RSAT/similar data	DES EPO	GPS, *dbf, GIS	5 years	
	Existing buffer widths	<i>Location, width</i>	DES EPO	GPS, *dbf, GIS		
	Tree canopy	<i>Area</i>	PRCR	GIS		PRCR implementing City-Green software
	Stream restoration projects	<i>Location</i> <i>Restoration type (e.g., bioengineering, rip-rap, etc.)</i> <i>Feet of stream restored</i> <i>Cost</i>	DPW, DES EPO, PRCR	GPS, *dbf, GIS	As proposed and completed	
	Long-term monitoring stations	<i>Location</i> <i>Physical data</i> <i>Biological data</i> <i>Chemical data</i> <i>Outfall location</i> <i>Monitoring data</i> <i>Rainfall data</i>	DES EPO	GPS, *dbf, GIS	As monitoring data is collected	
	NPDES Permit		DES EPO	*dbf, GIS	Monthly	
	Targeted BMP effectiveness and stream restoration monitoring	<i>Location</i> <i>Influent and effluent monitoring data</i>	DES EPO	GPS, *dbf, GIS		

Table 12. Data elements for Watershed Tracking System.
January 2001

2.8 Implementation plan

2.8.1 Key Recommendations

The key recommendations in the Watershed Management Plan and Chesapeake Bay Preservation Ordinance Task Force Report can be grouped into the following principal recommendations:

2.8.1.1 Expand street sweeping program

Space is very limited for stormwater facilities in ultra-urban areas like Arlington County. As a result, street sweeping is one of the most cost-effective approaches to removing the sediments and associated pollutants that accumulate on streets before they wash into streams. Clean streets also have an immediate pay-off in terms of community appearance and can help with economic development efforts.

2.8.1.2 Increase inspections and plan review staff

The key ChesBay Task Force recommendations focus on more comprehensive plan review and more frequent inspections of development sites. These recommendations will require additional staff, and their effective implementation also depends on staff trained in low-impact development principles. Inspections staff are also critical for inspecting development sites and inspecting and maintaining both existing and new stormwater facilities. Because of the potential for substantial redevelopment in Arlington, the ChesBay Ordinance and other ordinances provide opportunities for staff to encourage designs with fewer environmental impacts. Overall, this recommendation should result in more environmentally sustainable projects, fewer violations of County ordinances, fewer water quality problems, and fewer citizen complaints.

2.8.1.3 Revise ChesBay Ordinance

In addition to protecting more Resource Protection Areas, the major impact of revising the ChesBay Ordinance is the opportunity this will provide to improve water quality through the redevelopment process. However, several of the recommendations will require significant policy changes, including: i) developing a definition for open channels (e.g., dry swales and ditches, or only channels containing water or lined with concrete); ii) developing a straightforward process for citizens and developers to petition to add or remove an RPA designated property; iii) developing a simple process to administer exceptions or require reasonable water quality mitigation measures for small projects like decks and gazebos; iv) developing a defensible method to determine compliance with the ChesBay Ordinance's Performance Criteria, which provide potentially powerful tools to require environmentally sound site design; v) developing clear guidelines to determine when Source Control Fund contributions are, or are not, appropriate; vi) setting a Source Control Fund contribution rate that reflects the life-cycle costs of a BMP; and vii) assessing the appropriateness of the existing 38 percent County average impervious threshold, which must be exceeded before the water quality impacts of development are mitigated through a BMP or a contribution to the Source Control Fund.

2.8.1.4 Retrofit, build, and maintain stormwater facilities

Street sweeping does not address pollutants that accumulate on buildings or other impervious surfaces, pollutants like lawn fertilizers that wash onto streets during storms, or pollutants that are deposited by rainfall. To address these sources, stormwater quality facilities that treat runoff during storms are an important complement to a good sweeping program.

There are several stormwater detention facilities in the County, such as the Ballston Beaver Pond, that could be retrofitted to provide improved water quality treatment. In addition, innovative BMPs like the Stormceptor[®], which is an in-line filtering device, installed at the new Barcroft Sports Center, could be installed where appropriate and cost-effective. And, County staff should work closely with developers and their engineers during the site plan review process to encourage innovative designs and water quality BMPs such as bioretention and 'green' roofs. This approach has been pioneered by the City of Alexandria

through its Targets of Opportunity BMP program and was used successfully in Arlington during the recent Use Permit review process for the concrete batch plant located in Shirlington.

In addition, regular cleaning of storm sewer catch basins which collect a large volume of sediments and litter is important to reduce loadings of these pollutants to County streams. EPA recommends catch basin cleaning as a cost-effective part of an overall storm water management program, with important water quality and aesthetic benefits (EPA, 1999b). According to EPA, removal of sediment, debris, and polluted water from catch basins reduces foul odors, suspended solids, and the load of oxygen demanding substances that reach receiving waters. The agency recommends that catch basins should be inspected at least annually to determine if they need to be cleaned.

Also, inspecting and maintaining the County's up to 50-year old storm sewer system will identify problems that may be developing in the system such as clogged inlets, collapsed pipes, and leaking joints, as well as illicit connections prohibited under the County's Municipal Stormwater Permit. Collapsed pipes and leaking joints can saturate soils and cause sinkholes and flooding. Failing pipes can also allow dirt and sediment to enter stormwater, which carries the material out to streams and rivers. In addition, inspecting and maintaining the storm sewer system is important to protect the County's investment in this \$350,000,000 infrastructure.

2.8.1.5 Restore and maintain streams

The volume and velocity of runoff from existing impervious surfaces has taken its toll on County streams. Street sweeping and BMPs address water quality but not erosion and habitat problems caused by impervious cover. The stream inventory provides a prioritized list of stream restoration projects, in conjunction with citizen-identified problem areas. Restoring and maintaining the County's natural stream "infrastructure" can improve stream ecology, as well as enhance recreation and open space.

2.8.1.6 Monitor streams regularly

The stream inventory provided a planning level assessment of conditions County-wide, with an emphasis on physical stream habitat. More detailed data, particularly biological data, are needed to fully characterize and monitor changes in all County streams. Biological monitoring is crucial because aquatic organisms reflect the overall health of a stream. Since pollution incidents in urban streams tend to be sporadic, periodic chemical or physical monitoring alone will usually miss these incidents. Measuring the abundance and diversity of aquatic organisms provides one of the best performance measures to assess the health of local streams. Volunteer monitors will be critical to this effort.

2.8.1.7 Educate and involve residents

Arlington residents range from those who are well-versed in environmental issues to those who do not fully understand the role they play in environmental protection. Many residents do not make the personal connection between home and auto maintenance, lawn care activities, responsible pet waste disposal, or community development standards, and the impact of these activities on stream health. Television, radio, and various print media, as well as the Internet, and field programs will be critical tools to effectively communicate the connection between where and how we live and water quality and to emphasize the shared government and citizen responsibility for stream and riparian stewardship. Without active citizen involvement, County efforts will be much less effective.

2.8.2 Resource Implications for Proposed Implementation Plan

Determining the current resources devoted to watershed management is difficult because there are multiple programs, multiple agencies, and these programs are often not traced as a separate activity. The best estimate is that, at this time, approximately seven FTEs are allocated in DES, DPW, and PRCR to programs like erosion and sediment control inspections, plan review, stormwater permit monitoring, BMP maintenance, and stormwater master planning activities. An estimated \$2.6 million annually funds programs like the existing street sweeping and litter control programs, storm sewer maintenance, and the Four Mile Run flood control channel maintenance program. This total also includes amounts programmed in the CIP for flood management projects, BMP retrofits, and storm sewer system rehabilitation.

A Proposed Implementation Plan for the Watershed Management Plan and ChesBay Task Force recommendations is shown in Table 13 based on *planning level cost estimates* for FY 2002 – FY 2005. These proposals are designed to address the major deficiencies identified through the Watershed Management Plan, as well as to implement the key Chesapeake Bay Task Force recommendations. The Proposed Implementation Plan includes:

- Six new FTEs, phased in over the next three fiscal years to improve street sweeping, inspections, and plan review functions;
- Operating equipment to expand street sweeping program with two additional regenerative air sweepers, followed by purchase of one high-efficiency sweeper in FY 2003. If the high-efficiency sweeper performs well, additional high-efficiency sweepers could be added to the County equipment inventory as existing regenerative air sweepers are replaced;
- Training in better site design principles for County staff, as well as a new annual storm sewer catch basin cleaning program for all 10,000 catch basins in the County and a new storm sewer inspection and repair program that would survey 18 miles of storm sewer each year. All of these programs would be contracted out;
- Stormwater utility study in FY 2002 and watershed tracking system design in FY 2004; and,
- \$1.8 million in additional CIP funding through FY 2006 to begin a 20-year implementation schedule for expanding BMPs and stream restoration to address sites identified during the stream inventory, as well as to repair sanitary sewer system stream crossings.

On average, the estimated program costs require an additional \$1.2 million in annual operating and personnel expenditures and \$352,000 in additional CIP money each year. Actual costs by fiscal year are provided in the attached implementation plan.

Summary table:

	Existing	Additional proposed (FY 2002-FY 2005)
FTEs	7	6
Personnel (annual average)	\$280,000	\$260,000
Operating (annual average)	\$2,200,000	\$930,000
Capital (CIP annual average)	\$430,000	\$352,000

2.8.3 Funding

Stream restoration and protection requires a long-term programmatic, as well as financial, commitment to Arlington's environment. The existing CIP program and the approximately \$350,000 in the Source Control Fund can be used to begin funding some of the proposed watershed management programs, including stream restoration and street sweeping. Changing the Source Control Fund formula may increase this source of funding in the future. However, the cost of the proposed programs exceeds existing resources. And, although there are a number of grants available from state and federal agencies,

these funding sources, which will be explored where possible, cannot be relied upon as a long-term funding source.

There are other competing uses for the monies that fund the CIP and General Fund. The Watershed Management Plan and ChesBay Task Force both recommend that Arlington County seriously consider a dedicated, and potentially more equitable, funding source such as a stormwater utility to pay for stream restoration, BMPs, inspections and plan review staff, and other watershed management programs, as is done by a number of other Virginia jurisdictions.. The proposed implementation plan calls for a stormwater utility needs assessment and feasibility study to be conducted in FY 2002. The purpose of this study would be to determine if a stormwater utility could generate enough funds to cover both current and proposed expenditures for watershed management, replacing current CIP and General Fund sources for these activities.

2.8.4 Conclusion

Even today, after all the progress that has been made towards cleaning up the pollution from factories and wastewater treatment plants, the threats posed to streams by urban development and runoff remain one of the most difficult challenges facing local governments. The Watershed Management Plan provides a comprehensive framework for water resources management in Arlington County and helps us recognize that healthy urban streams are a key component of a sustainable community and a restored Chesapeake Bay. Even greater attention to "smart" growth management is critical if we are to successfully restore and protect our remaining streams and open spaces, not only for today's residents, but for future generations of Arlingtonians as well.

	FY 2002		FY 2003		FY 2004		FY 2005	
	DPW	DES	DPW	DES	DPW	DES	DPW	DES
Personnel								
Sweeper operator	0	2	0	2	0	2	0	2
Inspector	1	0	2	0	3	0	3	0
Plan reviewer	0	0	1	0	1	0	1	0
FTEs (new)	\$1	\$2	\$3	\$2	\$4	\$2	\$4	\$2
Subtotal Personnel²⁷	\$60,054	\$68,119²⁸	\$181,889²⁹	\$70,162	\$247,594	\$72,267	\$255,086	\$74,435
Operating								
Annual (Total)	\$603,836	\$77,988	\$607,672	\$147,462	\$611,508	\$147,462	\$611,508	\$167,462
RA sweeper maintenance and depreciation	\$0	\$12,988 ³⁰	\$0	\$62,462	\$0	\$62,462	\$0	\$62,462
Vehicle maintenance and depreciation	\$3,836	\$0	\$7,672	\$0	\$11,508	\$0	\$11,508	\$0
Storm sewer inspection/catch-basin cleaning contract	\$600,000	\$0	\$600,000	\$0	\$600,000	\$0	\$600,000	\$0
MS4 Permit monitoring contract	\$0	\$40,000	\$0	\$40,000	\$0	\$40,000	\$0	\$40,000
Volunteer monitoring program		\$5,000		\$5,000		\$5,000		\$5,000
WMP and CBPO outreach	\$0	\$20,000	\$0	\$20,000	\$0	\$20,000	\$0	\$20,000
Incremental HE sweeper maintenance and depreciation	\$0	\$0	\$0	\$20,000	\$0	\$20,000	\$0	\$40,000
One-time (Total)	\$18,253	\$295,000	\$45,253	\$170,000	\$43,253	\$25,000	\$0	\$145,000
RA sweeper cost	\$0	\$240,000	\$0	\$0	\$0	\$0	\$0	\$0
Wetland delineation	\$0	\$5,000	\$0	\$0	\$0	\$0	\$0	\$0
Stormwater utility study	\$0	\$50,000	\$0	\$0	\$0	\$0	\$0	\$0
Vehicle/laptop/radio (inspector)	\$18,253	\$0	\$18,253	\$0	\$18,253	\$0	\$0	\$0
Incremental HE sweeper cost	\$0	\$0	\$0	\$145,000	\$0	\$0	\$0	\$145,000
Computer (plan reviewer)	\$0	\$0	\$2,000	\$0	\$0	\$0	\$0	\$0
Site design training	\$0	\$0	\$25,000	\$25,000	\$0	\$0	\$0	\$0
Watershed tracking system	\$0	\$0	\$0	\$0	\$25,000	\$25,000	\$0	\$0
Subtotal Operating	\$622,089	\$372,988	\$652,925	\$317,462	\$654,761	\$172,462	\$611,508	\$312,462
Total Personnel and Operating Costs	\$682,143	\$441,107	\$834,814	\$387,624	\$902,355	\$244,729	\$866,594	\$386,897
Less General Fund (GF) request	\$0	\$35,000 ³¹	\$0	\$35,000	\$0	\$35,000	\$0	\$35,000
Less Revenues	\$0	\$270,000 ³²	\$0	\$25,000	\$0	\$25,000	\$0	\$25,000
Net GF Tax Support - By Dept.	\$682,143	\$136,107	\$834,814	\$327,624	\$902,355	\$184,729	\$866,594	\$326,897
Net GF Tax Support - FY Total		\$818,250		\$1,162,438		\$1,087,084		\$1,193,491
Change from Previous FY		\$818,250		\$344,189		(\$75,354)		\$106,407
FY 02 Storm Drainage CIP ³³		\$0		\$1,104,000		\$43,000		\$1,218,000
Total - GF and CIP		\$818,250		\$2,266,438		\$1,130,084		\$2,411,491

Table 13. Proposed Implementation Plan.

²⁷ Salary and benefits for one inspector (Grade 10, Step 6) and two sweeper operators (MVO3, Step 2). For inspectors, FY 2003 and FY 2004 personnel costs assume additional inspectors hired at Grade 10, Step 6 with annual step increases for all inspectors at 3 percent until Step 8, when biannual step increases begin (inspector hired in FY 2002 reaches Step 8 in FY 2004). For sweeper operators, FY 2003 through FY 2005 personnel costs assume annual step increases at 3 percent.

²⁸ Sweeper operator personnel costs plus 200 hours of overtime to shorten Spring sweeping program to 5 weeks.

²⁹ Plan reviewer, Grade 10, Step 6. FY 2003 to FY 2005 personnel costs assume annual step increases at 3 percent.

³⁰ Assumes one-half year of maintenance in the first year for each sweeper.

³¹ \$35,000 in DES base budget for MS4 Permit monitoring contract beginning in FY 2002.

³² Contribution from Source Control Fund for FY 2002 (\$25,000 for FY 2003 through FY 2005).

³³ Changes in existing funding requested for BMPs, stream restoration, and system renovation/rehab. projects.

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4 Acronym List

ACE	Arlingtonians for a Clean Environment
ANCC	Army-Navy Country Club
ANS	Audubon Naturalist Society
BAT	Best Available Technology
BMP	Best Management Practice
BNR	Biological Nutrient Reduction
CBLAD	Chesapeake Bay Local Assistance Department
Cfs	Cubic foot per second
COG	Metropolitan Washington Council of Governments
CPHD	Arlington County Department of Community Planning, Housing and Development
CWP	Center for Watershed Protection
DCR	Virginia Department of Conservation and Recreation
DEA	Dog Exercise Area
DED	Arlington County Department of Economic Development
DEQ	Virginia Department of Environmental Quality
DES	Arlington County Department of Environmental Services
DPW	Arlington County Department of Public Works
E&S	Erosion and sediment
ECC	Arlington County Emergency Communications Center
EMC	Event Mean Concentration
EPA	U.S. Environmental Protection Agency
EPO	Arlington County DES Environmental Planning Office
ESA	Environmental Systems Analysis, Inc.
GIS	Geographic Information System
GLUP	General Land Use Plan
I&I	Infiltration and Inflow
LEED	Leadership in Energy and Environmental Design
MS4	Municipal Separate Storm Sewer System
MS-19	Minimum Standard 19
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NURP	Nationwide Urban Runoff Program
NVPDC	Northern Virginia Planning District Commission, now Northern Virginia Regional Commission
NVSWCD	Northern Virginia Soil and Water Conservation District
PRCR	Arlington County Department of Parks, Recreation, and Community Resources
RPA	Resource Protection Area
RSAT	Rapid Stream Assessment Technique
SWMP	Storm Water Master Plan
TDS	Total dissolved solids
TMDL	Total Maximum Daily Load
TPH	Total petroleum hydrocarbons
TSS	Total suspended solids
USACOE	U.S. Army Corps of Engineers
USGBC	U.S. Green Building Council
USGS	U.S. Geological Survey
VCE	Virginia Cooperative Extension
WPCP	Water Pollution Control Plant
WSS	Arlington County DPW Water, Sewer, and Streets Division

5 Glossary

Bankfull Flow: Condition where flow fills a stream channel to the top of bank and at a point where the water begins to overflow onto a floodplain.

Best Management Practices (BMPs): Best Management Practices are structural or nonstructural practices, or a combination of practices, designed to act as effective, practicable ways to minimize the impacts of development and human activity on water quality. Structural BMPs, which include extended detention dry ponds, wet ponds, infiltration trenches, sand filters, and in-line filters, rely heavily on gravitational settling and/or infiltration through a porous medium for pollutant removal. Nonstructural BMPs range from programs that increase public awareness to prevent pollution to vegetation-utilizing controls such as bioretention areas or wetlands (NVRC, 1996).

Bioengineering: A method of construction using living plants, or plants in combination with dead or inorganic materials. The practice brings together biological, ecological, and engineering concepts to produce living, functioning systems to prevent erosion, to control sedimentation, and/or to provide habitat.

By-right Development: The type and level of development allowed in a certain zoning district depending on the classification of that district.

Capital Improvement Program (CIP): A planning tool which provides funding guidelines for the future infrastructure needs of Arlington County.

Catch Basin: An inlet chamber usually built at the curb line of a street or low area, for collection of surface runoff into a storm sewer or subdrain.

Channel Erosion: The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to large floods.

Chesapeake Bay Preservation Ordinance: As required by Virginia's Chesapeake Bay Preservation Act (1988), this ordinance authorizes the County Board to designate Chesapeake Bay Preservation Areas within which future development must meet performance criteria designed to reduce nonpoint source pollution and/or protect the most sensitive lands from disturbance. Those performance criteria include:

- Limiting land disturbance and impervious cover to the amount necessary to provide for desired use or development.
- Preserving indigenous vegetation as much as possible consistent with use.
- Strictly controlling soil erosion during clearing, grading and construction.
- Controlling stormwater runoff and its quality, in many cases by employing best management practices (BMPs), which are natural features or engineered devices that trap runoff and detain it to allow pollutants to settle or filter out.

Erosion and Sediment Control Ordinance: As required by Virginia's Erosion and Sediment Control Act, requires individuals engaging in land-disturbing activities, such as construction, to submit an erosion and sediment control plan to the County. This plan must be approved by the County before the work can begin. Applicants and County staff refer to the "Virginia Erosion and Sediment Control Handbook" in designing and approving the control measures.

Event Mean Concentration: Flow-weighted concentration of an analyte averaged over the entire length of a sampling event.

Fecal Coliform Bacteria: Bacteria that are associated with fecal material and are used to indicate the possible presence of other waterborne pathogenic bacteria, viruses or parasites.

Illicit Non-stormwater Discharges: Illegal and/or improper waste discharges into storm drainage systems and receiving waters, including residential or commercial wastewater or hazardous materials such as motor oil or paint.

Impervious Cover: Any surface in the urban landscape that cannot effectively absorb or infiltrate rainfall (e.g., streets, sidewalks, parking lots, and buildings).

Infiltration: The downward movement of water from the ground surface to the subsoil and eventually into the groundwater system.

In-line BMP Devices: Devices that are placed internally along the length of a storm sewer system to filter, treat, or otherwise improve the water quality of stormwater runoff before it enters a waterway.

Invasive Species: Species that are not native to an area, and which can compete aggressively with native species. In their new locations, invasive species lack the natural controls such as predators or disease that keep them in balance in their native ecosystem.

Macroinvertebrates: Aquatic insects that live in stream habitats and can be used as indicators of stream health. The various species of macroinvertebrates have different levels of sensitivity to changes in stream habitat, with some being very sensitive and other being very tolerant of pollution.

Municipal Separate Storm Sewer System (MS4) Permit (see also Virginia Pollutant Discharge Elimination System Permit): Issued by the Virginia Department of Environmental Quality, this permit governs discharges of stormwater and non-stormwater through Arlington County's storm sewer system, and requires the County to monitor storm water runoff at representative storm sewer outfalls, to screen major storm sewer outfalls for illicit discharges, and to demonstrate that the County has effective management practices in place to reduce storm water pollution to the "maximum extent practicable."

Non-point source pollution: Contaminants such as sediment, nitrogen and phosphorous, hydrocarbons, heavy metals, and toxins whose sources cannot be pinpointed but rather are washed from the land surface in a diffuse manner by stormwater runoff.

Outfall: Location where effluent is discharged into receiving waters.

Point Source Pollution: The discernible, confined and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, container, concentrated animal feeding operation, or landfill leachate collection system from which pollutants may be discharged.

Resource Management Area (RMA): As defined in Arlington's Chesapeake Bay Preservation Ordinance, RMAs are lands in which improper development will also degrade water quality or diminish the functional health of the Resource Protection Area. Any use allowed under local zoning is permitted in an RMA, but all new development and redevelopment must meet the performance criteria.

Resource Protection Area (RPA): As defined in Arlington's Chesapeake Bay Preservation Ordinance, RPAs are lands with the greatest importance for water quality. They generally include streams and other open watercourses, wetlands, and shorelines, as well as a buffer area at least 100 feet wide on the landward side of these natural features. Within RPAs, activities are generally limited to water-dependent uses such as piers and the redevelopment of existing uses. Requests to develop within RPAs require analysis of the water quality impacts of such development.

Rip Rap: A combination of large stone, cobbles, and boulders used to line channels, stabilize banks, reduce runoff velocities, and filter out sediment.

Riparian Buffers: A vegetated or forested area adjacent to a shoreline, wetland, or stream that helps "filter" pollutants and bacteria before they enter the waterway. Development is generally restricted or prohibited in these buffer zones.

Rapid Stream Assessment Technique (RSAT): a field screening approach developed in 1992 by John Galli of the Metropolitan Washington Council of Governments (COG) to conduct watershed-wide analyses for Piedmont streams (Galli, 1996). RSAT incorporates chemical, biological, and physical indicators to evaluate stream health relative to a reference stream known to have reaches in good condition.

Sanitary Sewer: A system of pipes, separate from storm sewers, that carries wastewater from homes and businesses to a wastewater treatment plant. In some older urban jurisdictions, the sanitary sewer system and storm sewer system are combined.

Source Control Fund: A fund established under Section 61-9 of the Chesapeake Bay Ordinance that can be used for water quality improvements and watershed education. Developers can contribute to this fund in lieu of creating BMPs on properties that they develop. The intent of allowing this contribution is to minimize the proliferation of small BMPs which can be difficult to inspect and maintain.

Storm Sewer: A system of pipes, separate from sanitary sewers, that only carries runoff from buildings and land surfaces directly to streams. In some older urban jurisdictions, the sanitary sewer system and storm sewer system are combined.

Stormwater Detention Ordinance: This County ordinance requires new development to maintain runoff characteristics similar to those of undeveloped land, regardless of prior land use.

Stormwater Utility: A fee paid by all users of the storm sewer network in a municipality with is used to address impacts of stormwater runoff. The fee is proportional to the user's contribution to stormwater runoff, as estimated through a measure of the amount of impervious cover on the lot.

Total Maximum Daily Load (TMDL) Regulations: A TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Water quality standards are set by States, Territories, and Tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.

Vegetated Roofs: A thin layer of soil and plants placed on the roof of a building, which absorbs rainfall to reduce stormwater runoff, provides additional building insulation, improves air quality, and absorbs

sunlight to reduce the temperature of the roof, which cools the interior of the building and extends the life span of the roof.

Virginia Pollutant Discharge Elimination System (VPDES) Permit (see also Municipal Separate Storm Sewer System Permit): Issued by the Virginia Department of Environmental Quality, this permit governs discharges of stormwater and non-stormwater through Arlington County's storm sewer system, and requires the County to monitor storm water runoff at representative storm sewer outfalls, to screen major storm sewer outfalls for illicit discharges, and to demonstrate that the County has effective management practices in place to reduce storm water pollution to the "maximum extent practicable."

Watershed: All the land area that contributes runoff to a particular portion of a waterway.

Zoning: A set of regulations and requirements that govern the use, placement, spacing, and size of buildings and lots within a specified area or in a common class (zone).